

Emotional Stress and Eyewitness Memory: A Critical Review

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The eyewitness literature often claims that emotional stress leads to an impairment in memory and, hence, that details of unpleasant emotional events are remembered less accurately than details of neutral or everyday events. A common assumption behind this view is that a decrease in available processing capacity occurs at states of high emotional arousal, which, therefore, leads to less efficient memory processing. The research reviewed here shows that this belief is overly simplistic. Current studies demonstrate striking interactions between type of event, type of detail information, time of test, and type of retrieval information. This article also reviews the literature on memory for stressful events with respect to two major theories: the Yerkes-Dodson law and Easterbrook's cue-utilization hypothesis. To account for the findings from real-life studies and laboratory studies, this article discusses the possibility that emotional events receive some preferential processing mediated by factors related to early perceptual processing and late conceptual processing.

It is often claimed in the eyewitness literature that emotional stress leads to an impairment in memory and, hence, that details of negative emotional events are remembered less accurately than details of neutral events. For example, in a survey of 63 experts on eyewitness testimony made by Kassin, Ellsworth, and Smith (1989), there was a strong consensus that stress or event violence is bad for memory. In particular, the experts were asked whether they agreed with the statement: "Very high levels of stress impair the accuracy of eyewitness testimony." In response to this question, the majority of the experts (79%) agreed that the available evidence tends to favor this statement, and 71% of the experts said the statement was sufficiently reliable to offer it in court. Are these experts right?

Over the past 20 years, psychological research has produced a wide variety of results concerning memory for negative emotional events. Some studies have shown that unpleasant events are retained quite well (e.g., Bohannon, 1992; Brown & Kulik, 1977; Heuer & Reisberg, 1990; Holmes, 1970; Yuille & Cutshall, 1986, 1989). Other studies have shown that negative emotional events are retained poorly compared with neutral events (e.g., Clifford & Hollin, 1981; Clifford & Scott, 1978; E. F. Loftus & Burns, 1982; Neisser & Harsch, 1990; Peters, 1988). Still other studies have demonstrated striking interactions between type of event (emotional/nonemotional) and type of detail informa-

tion (central/peripheral; e.g., Burke, Heuer, & Reisberg, 1992; Christianson & Loftus, 1987, 1991; G. S. Goodman, Hepps, & Reed, 1986), type of test (free recall, cued recall, recognition; e.g., Christianson & Nilsson, 1984; P. J. Davis, 1990; Wagenaar, 1986), or time of test (immediate or delayed; e.g., Burke et al., 1992; Christianson, 1984; Levonian, 1967). This diversity in research findings raises serious concerns about claims that negative emotional events are either well retained or poorly retained in memory.

My aim is to review current research on this issue and to discuss this research in relation to the Yerkes-Dodson (1908) law and the Easterbrook (1959) cue-utilization hypothesis. These two theoretical accounts are emphasized in this review simply because they are, without comparison, the two most cited theories in the eyewitness memory literature. There are, of course, other contemporary theories on emotion and memory that could be relevant in this context (e.g., Bower, 1981; Bower & Cohen, 1982; Ellis & Ashbrook, 1988, 1989; Hasher & Zacks, 1979; Ingram, 1984; M. K. Johnson, 1985; M. K. Johnson & Multhaup, 1992). However, most of these contemporary views do not specifically consider how different levels of emotional arousal or stress influence memory. This quantitative aspect of emotion and arousal-stress has been of considerable importance in eyewitness memory research, and the two major theories, at least to my knowledge, that explicitly deal with this aspect are the Yerkes-Dodson law and the Easterbrook hypothesis.

Note that the present study exclusively focuses on memory for negative emotional events and information associated with those events. Accordingly, positively valenced events are not considered. The terms *negative emotional events* and *emotional stress* have been used rather loosely in the eyewitness literature and have often varied across different studies. Some clarification of these concepts on which the present review is based is therefore needed. I use the term *negative emotional events* to refer to events that are new, unexpected, and potentially threatening. Such unpleasant and stressful events can be experienced either in real-life settings or in laboratory settings. The labora-

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tory-induced negative emotional events are considered here as distinct events or scenes that have unpleasant visual features (e.g., blood, injuries) and have the potential to evoke strong unpleasant feelings (emotional stress) in the viewer. These negative emotional-stressful events are equivalent to what have been described as *violent events*, *shocking events*, *traumatic events*, or *events of impact* by various authors in the eyewitness literature. The term *emotional stress* as a state is defined here as a consequence of an negative emotional event, in which the person experiences a certain degree of stress or distress with concurrent autonomic-hormonal changes. This state can range from moderate levels of stress to excessive levels of traumatic emotions, in which the person is overwhelmed by threat and fear and incapable of coping with the traumatizing event. Measurements of physiological reactions associated with emotional stress sometimes show a pattern of an orienting response and sometimes a pattern of a defensive or a rejection response (Graham & Clifton, 1966; Lacey, 1967).¹ Note, however, that a strong emotional response is not necessarily an immediate or a conscious reaction to an emotional event. Moreover, as discussed by Panksepp (1982), some characteristics of emotional stimuli, with certain affective quality and intensity, may trigger certain primitive emotional reactions. These emotional reactions are believed to be genetically hard wired: They presumably evolved as humans coped with life-threatening or fear-evoking events (see also the section on preattentive processing-emotional priming below).

Another restriction of this review is that it does not examine research on general effects of nonspecific arousal (Eysenck, 1982; Revelle & Loftus, 1990), mood (Blaney, 1986; Bower, 1981; Ellis & Ashbrook, 1989; Kuiken, 1989), or emotional disorders (M. H. Johnson & Magaro, 1987; Williams, Watts, MacLeod, & Mathews, 1988) on memory. Or how emotion interacts with age (Ceci, Toglia, & Ross, 1987; G. S. Goodman, Hirschman, Hepps, & Rudy, 1991), sex (Kuehn, 1974; MacLeod & Shepard, 1986), and personality factors (Eysenck, 1982; Polans, 1985; Revelle, Anderson, & Humphreys, 1987). This article provides a different perspective on how emotion influences memory than the reviews already available in that the organization here is around eyewitness memory for stressful events, focusing on what people retain from stressful events rather than on how people perform (i.e., their general efficiency) under various affective states or different levels of physiological arousal.

A few distinctions will make the focus of this review clearer. One distinction is that between *arousal (stress) per se*, which refers to the level of arousal experienced by the rememberer, and *emotionally arousing events*, which refers to the valence of the to-be-remembered (TBR) event, independent of the arousal of the rememberer. Although arousal and valence most often go together, there are some situations in which they do not, and it is therefore important to distinguish between these two aspects carefully. For example, it is important that assumptions regarding emotional arousal of a witness are not made only on the basis of the content of an emotional event. This is especially crucial in laboratory studies when the TBR information consists of emotionally provoking words or stories or only mildly unpleasant pictures, which are not likely to induce high levels of emotional arousal or stress. It is also important to differentiate between situations in which the TBR event is accompa-

nied by emotional arousal that is evoked by the TBR material proper and situations in which the source of the arousal is dissociated from the TBR event. For example, in seminal work about emotion and memory in the eyewitness literature (Defenbacher, 1983; E. F. Loftus, 1979; E. F. Loftus & Doyle, 1987), the authors commonly refer to situations in which subjects are asked to perform during highly arousing or stressful circumstances (e.g., loud noise, failure stress, worry about a threatening experimental situation). Much of this research concerns memory for events that are dissociated from the source of stress. This type of research describes how well subjects retrieve information in general during a state of being highly aroused, not what the subjects retain from the eliciting negative emotional event itself.

In a textbook on memory, Elizabeth Loftus, who is the main authority in eyewitness memory research, provides several examples of such effects of dissociated arousal in discussing the relationship between memory and emotion: "In a moment of intense fear, you would probably still be able to tell someone your name, but you would have trouble playing a Beethoven sonata on the piano" (E. F. Loftus, 1980, p. 80). In another example, Loftus refers to a study by Baddeley (1972), in which servicemen were taken on a plane flight and were deceived into believing that an emergency situation had arisen. The study indicated that a simulated emergency impairs ability to remember detailed instructions. In a third example, Loftus refers to her own research in which people who greatly feared snakes were shown a film of a complex event that they had to remember later on. This experimental situation is a bit different from the Baddeley example; the subjects were aroused during encoding, but the TBR information was not at all associated with the stressor. The experiment showed that subjects who watched the film with a snake nearby did much worse on the subsequent test than those who saw the film with a teddy bear nearby (E. F. Loftus, 1980, pp. 80-81). Obviously this type of test situation is far from a perfect analogue of a traumatic eyewitness situation, in which the source of the emotional stress is also the TBR event. In an eyewitness situation, the issue of interest is what an eyewitness remembers about a traumatic event, not what the witness is able to retrieve from memory in the midst of the traumatic experience. This article is concerned with memory for the content of negative emotional events rather than general memory performance at states of high emotional arousal or stress elicited by an extraneous source that is dissociated from the TBR event. Thus, assumptions regarding emotional stress and memory are made on the basis of people's recollection of emotional TBR events, which are also emotionally arousing and stressful.

Another important distinction made in this review is that between asking for specific detail information about the emo-

¹ In psychophysiological studies, an increase in palmar activity combined with a decrease in heart rate is generally considered to be part of an orienting response. This pattern of autonomic responses is a common reaction to unpleasant stimulation (see e.g., Hare, Wood, Britain, & Shadman, 1971; Klorman, Weissberg, & Wiesenfeld, 1977). A defensive response (i.e., increased palmar and cardiac activity) is typically evoked by strongly unpleasant or traumatic stimulus events (see, e.g., Christianson, 1987).

tional event proper versus asking for information that is associated with the emotion-eliciting event, such as peripheral, or noncentral, information about occurrences within an emotional scenario or details that precede or succeed the emotional event. For example, in many laboratory simulations of amnesia, it is often shown that the emotionally arousing event (i.e., the *amnesic agent*) is retained very well but that detail information surrounding the emotional event is retained less well. This article distinguishes between two classes of TBR information: first, memory for emotionally loaded detail information of an emotionally arousing event (e.g., a boy being hit by a car and bleeding from an eye injury) and, second, memory for information surrounding an emotional event, that is, neutral detail information occurring within an emotional scenario (e.g., a car seen driving in the background). Studies in which both classes of details have been examined are reviewed in this article.

Empirical Findings

To witness an emotional event such as a car accident, a shooting, or an assault is a highly emotional experience by anyone's criterion. How will such emotional events be remembered by a victim, a bystander, or a perpetrator? What specific details will be retained, and what will be lost? How will these emotional events be remembered compared with more ordinary, less emotional events? These questions about memory for highly unpleasant or traumatic events have been studied by researchers and clinicians using a variety of methods. One approach is to interview witnesses or victims of actual traumatic events and explore their memories, for example, case studies (Christianson & Nilsson, 1989), field studies (Yuille & Cutshall, 1986), or interviews about public (Brown & Kulik, 1977) or private (Rubin & Kozin, 1984) traumatic events. Another approach is to investigate memory for traumatic events in laboratory settings (including staged events), in which subjects are exposed to simulated crimes, accidents, and other emotional events and the accuracy of their memories are tested (e.g., Clifford & Scott, 1978; Heuer & Reisberg, 1990; Hosch, Leippe, Marchioni, & Cooper, 1984; E. F. Loftus & Burns, 1982; Read, Yuille, & Tollestrup, in press).

Whereas real-life studies concerning traumatic events tend to show that these events are well preserved in memory, many simulation studies claim to show that traumatic events are poorly retained. To better understand the seemingly paradoxical empirical findings, we need to carefully look at various studies in the field of emotion and memory, and see whether the memories in these two settings are qualitatively different or whether the incongruence in research findings can be explained by differences in the type of detail information examined, differences in type of test, time of test, and so on. The present review first examines studies of real-life experiences and thereafter laboratory findings, predominantly research that relates to eyewitness studies.²

Studies of Real-Life Events

Clinical Observations

An early attempt to study the impact of emotion on memory was presented by Sigmund Freud. By using a psychoanalytical

approach in his clinical work with hysterical patients, Freud found that people banish unacceptable and anxiety-provoking memories from consciousness to avoid emotional confrontation. He assumed that patients are occasionally confronted with thoughts that, for a variety of moral and other reasons, are too painful and are therefore simply repressed. That is, we avoid unpleasant memories by keeping them out of awareness or consciousness (see Breuer & Freud, 1895/1955; Erdelyi & Goldberg, 1979; Freud, 1915/1957; see also Singer, 1990, for a review of the concept of repression). A reasonable inference from Freud's case studies is that the difficulties in remembering negative emotional experiences are due to a limited accessibility rather than a limited availability to these experiences. Freud's psychoanalytical approach is not particularly satisfying for a number of reasons. First, Freud's studies included in-depth analyses with a collection of patients whose actual life experiences can never be precisely known. Thus, it is difficult to know precisely what memories, if any, are or are not being repressed. Nor can we know the accuracy of what is recalled. Second, the concept of repression provides no explanation for the fact that some details from traumatic events are retained quite well.

Field Reports and Interviews

Another method is to analyze data from police reports about victims of traumatic events. Kuehn (1974) took this approach and concentrated specifically on the capability of victims of violent crimes to provide descriptions of those crimes to the police. On the basis of the reports of victims of 2 homicides (the victims lived long enough to provide some information), 22 rapes, 15 assaults, and 61 robberies, Kuehn found that victims of robberies provided fuller descriptions than did victims of rape or assault. He also found that injured victims—no matter what the type of crime—provided less information than did noninjured victims, which means that more information was retained in the case of the less serious crimes. In terms of information provided about the assailant, most victims could identify the gender of their assailant (93%), whereas they rarely could describe the assailant's eye color (only 23% did so). The other traits of the assailant that were described in more than 70% of the cases were in this order of frequency: age, height, build, race, weight, complexion. On the basis of these data, Kuehn concluded that obvious physical characteristics like gender, build, or height were more frequently identified than, for example, hair color or eye color.

Yuille and his colleagues (Yuille & Cutshall, 1986, 1989; Yuille & Tollestrup, 1992) adopted a different approach and interviewed witnesses to actual crimes. In a study by Yuille and Cutshall (1986), 13 witnesses to a murder were interviewed soon after the crime occurred (all witnesses provided information to the police within 2 days of the murder) and again 4–5 months later. The results showed a high degree of accuracy of memory and little decline over time. For example, color of

² It is beyond the scope of this article to review all research done in this area of study. I therefore concentrate on those studies that are most commonly referred to in the eyewitness literature.

clothing was found to be the most difficult feature to retain, yet the accuracy level for colors of clothing of the central character was quite high, varying between 66% and 83% correct. Furthermore, those subjects who reported the highest amount of stress showed a mean accuracy of 93% in the initial police interview and a mean accuracy of 88% 4–5 months later. On the basis of the results from this study and similar studies using the same approach (Fisher, Geiselman, & Amador, 1989; Yuille & Cutshall, 1989), Yuille and Tollestrup (1992) concluded that an emotional response to an event does not affect memory negatively.

According to Yuille and his colleagues, this type of approach, in which traumatic events are studied as they naturally occur, is the only way to study the impact of strong emotion on memory. They argue that laboratory studies cannot simulate a situation that threatens a subject's property or physical and mental health and therefore lead to qualitatively different memories. Although witnessing a genuine trauma is far more emotionally arousing than witnessing a simulated accident in a laboratory setting, the field study approach has its obvious limitations too. Determination of the effects of emotional stress on accuracy cannot be assessed fully because one does not know what actually happened. For example, Yuille and Cutshall (1986) concluded that the stress level at the time of the traumatic event does not appear to affect memory negatively. However, in their study, stress was not measured objectively. They provided only a single stressful event and no neutral event with which to compare it. Even when witnesses are grouped on the basis of self-reports as to who was more or less emotionally aroused by this evocative event, level of emotional stress remains confounded with other variables, such as vantage point and motivations for cooperation. Thus, no full interpretation of the findings is possible (see also J. Goodman & Loftus, 1989, for a further discussion of these validation problems).

Adopting a similar approach to that of Yuille and Cutshall (1986), Christianson and Hübner (in press) examined witnesses' memory and emotional reactions from 22 post office robberies. A total of 58 witnesses who had observed a post office robbery, either as a victim (a teller under gunpoint) or a bystander (fellow employee or customer), were asked to fill out a questionnaire concerning their emotional reactions during the robbery and their memory for specific event information. The consistency of the witnesses' accounts were measured by a comparison of the information in the police reports and the recollections given in the written research interview between 4 and 15 months after the robberies. The results indicated that the witnesses' recollections of detailed information concerning the actual robbery (e.g., action, weapon, clothing), were consistent, whereas recollections of the specific circumstances (e.g., date, time, other people) were less consistent with what was reported in the police report. The results also showed significantly higher accuracy rates among victims than bystanders, which is in line with Yuille and Cutshall's (1986) study of a shooting incident. This latter result, however, does not seem to be related to differences in arousal during the robbery, because ratings of emotional reactions indicated that victims were not more emotionally aroused than bystanders (see Hosch & Bothwell, 1990, for similar results). Taken together, the results of Christianson and Hübner's study indicate that highly emo-

tional events are well retained over time with respect to details directly associated with the emotional-arousing event, but less so with respect to details of the concomitant circumstances of the event.

Another variation on the witness interview approach involves simply asking people about their memories for very negative emotional events. In a survey of people's autobiographical memories, Reisberg, Heuer, McLean, and O'Shaughnessy (1988) found that the more intense the emotional event, the higher confidence in memory. In a similar study by Christianson and Loftus (1990), over 400 subjects were asked to report their most traumatic memory and to answer questions about their chosen memory. A major finding was a significant relationship between rated degree of emotion and the number of central details, but not peripheral details, the subjects believed that they remembered. Thus, according to these two survey studies, there seems to be a significant correlation between affect strength and rated memory vividness.

In a study of extremely emotional experiences, such as being a victim of a Nazi concentration camp, Wagenaar and Groeneweg (1990) compared testimonies from 78 former prisoners of Camp Erika collected in the periods of 1943–1947 and 1984–1987. A comparison between testimonies from these two periods revealed that almost all witnesses remembered the concentration camp experiences in great detail even after 40 years. Although errors did occur, Wagenaar and Groeneweg found recall of the conditions in the camp and smaller details to be remarkably consistent and accurate.

A further variation on the witness interview approach is the study of so-called "flashbulb memories" (Brown & Kulik, 1977; see also Winograd & Neisser, 1992, for a review of research on flashbulb memories). The term refers to the phenomenon that a person who experiences a traumatic newsworthy event (e.g., being told about the assassination of one's president) often reports a vivid memory for the emotionally shocking news itself but also for the specific circumstances under which the unpleasant news was told: the informant, the location, the time, any ongoing activity, the subject's own clothing, the subject's own affect, and so on.

Since the original study by Brown and Kulik (1977), numerous studies have shown an impressive concordance in subjects' memory of shocking national events, such as assassinations (Bohannon, 1988; Christianson, 1989; Colgrove, 1899; Pillemer, 1984; Rubin & Kozin, 1984; Winograd & Killinger, 1983). The news events and the concomitant circumstances have most often been found to be consistent with earlier telling, even over very long retention intervals, such as 1 year or longer after the occurrence of the event (e.g., Bohannon, 1992; but see Neisser & Harsch, 1990, for inconsistent findings). Furthermore, specific analyses used to investigate whether higher levels of emotion would yield less or greater accuracy in recollection of detailed information in flashbulb memories indicate that ratings of intense levels of emotion are associated with better, rather than worse, recall of the flashbulb circumstances (Bohannon, 1992; Christianson, 1989; Pillemer, 1984).

Several interpretations of this phenomenon have been presented. Some advocate biological-evolutional factors (Bohannon, 1988, 1992; Brown & Kulik, 1977; Gold, 1986, 1992); some emphasize psychological mechanisms, such as reconstructive

processes (E. F. Loftus, 1982; Neisser, 1982) or other ordinary memory mechanisms (McCloskey, Wible, & Cohen, 1988). Among those advocating biological mechanisms, Brown and Kulik (1977) and Schmidt and Bohannon (1988) maintain the position that people have an inherent special mechanism that is triggered when an event is highly emotionally arousing, surprising, and consequential. This mechanism is considered to be of great importance for our survival and has been referred to in the flashbulb literature as a neuropsychological "Now print!" mechanism (see Livingston, 1967), which is supposed to preserve a photographic image of the critical event in our brain. This interpretation has been disputed, for example, by McCloskey et al. (1988), who claim that a postulation of a special memory mechanism that is triggered when one experiences an emotional event is warranted only if there is evidence that these memories cannot be products of our ordinary memory mechanisms (see also Bohannon, 1992; Cohen, McCloskey, & Wible, 1988; McCloskey, 1992; Neisser, 1982; Pillemer, 1990, for further discussions of a specific flashbulb/Now print! memory mechanism). Although it is clear that people remember these sorts of events better than they do ordinary events that occurred equally long ago, by no means are flashbulb memories completely accurate. Empirical evidence indicating that people do not retain flashbulb events and attendant circumstances as photographically complete memories, as some believe, has been presented by, for example, McCloskey et al. (1988) and Neisser (1982).

One main problem with flashbulb studies, as in most other studies of real-life events, is that these studies do not include a baseline measure, that is, a comparable, salient, everyday event. In an attempt to include such a control event, Christianson (1989) found a higher recall performance for the flashbulb event as compared with the salient control event. However, the method of measuring the control event was far from perfect in the Christianson (1989) study. For example, the flashbulb questions concerned circumstances surrounding a known event, but the control event question did not. The compatibility between the flashbulb event and the ordinary event was therefore very low. In a more thorough study, Larsen (1992) collected news events and everyday personal experiences in a diary over 9 months. In this study, both extremely upsetting and ordinary news events and personal events were included, and Larsen was able to provide a most appropriate baseline against which to evaluate flashbulb memories. Larsen found that as surprise and importance of the news increased, memory of the reception context deteriorated, but memory for the news itself improved. This finding is analogous to the pattern of data obtained in many laboratory studies of emotional events (see studies concerning central and peripheral detail information below) but opposite to the traditional picture of flashbulb memories.

Because there are several difficulties involved in either including a comparable control event or knowing what actually happened at the time of the event, one way to verify the accuracy and consistency of flashbulb memories is to ask people a series of questions about the circumstances in which they first learned about the shocking event and then ask the same questions again later to compare the consistency between the recollections reported on the two occasions. This double assessment technique has been used by several researchers (Bohannon,

1992; Christianson, 1989; McCloskey et al., 1988; Pillemer, 1984) and has shown a fairly good consistency over longer retention intervals. One problem with this technique, however, is that we cannot tell how accurate people really are in their initial descriptions of the flashbulb event and its concomitant circumstances. Unlike laboratory studies, there is often no way of knowing in flashbulb studies what the subjects were actually doing, wearing, and so on when they were presented the shocking news. The initial recalls may not have been truthful or accurate observations of the original situation when the news was first delivered. They may very well be reconstructive and presumably contain some erroneous information, as most other types of memories. An important question is then, What proportion of the initial memories or what particular details are of this sort? A second recall of the event and its concomitant circumstances quite likely will produce the same memory for some core elements, but many plausible details will be added or constructed (see work by E. F. Loftus, 1979; Winograd & Killinger, 1983, for a discussion of influences on people's original recollections).

Although flashbulb memories may very well be partly a reconstructive process and may contain some erroneous information, they do indicate that the memory of the emotional event itself and of some detail information is very well preserved over time. That is, the loss of clarity and detail over time seems to be far less for these emotional memories than can be seen from the forgetting curve typically found in basic memory research (Murdock, 1974). Furthermore, although flashbulb memories do not concern details of the emotion-eliciting event itself, but surrounding or associated information details, and the relationship here between memory and the emotion-eliciting event is to some extent indirect, these studies do suggest that intense, emotionally arousing events are relatively well retained. Still, there is no evidence that flashbulb memories differ from memories of other sorts of emotional events.

In summary, the results from flashbulb studies and other studies of real-life events suggest that highly emotional or traumatic events are very well retained over time, especially with respect to detailed information directly associated with the traumatic event.

Laboratory Studies

In real-life studies of highly emotional memories, one usually does not know for sure what the original circumstances were, only what the person claims that they were. To circumvent these difficulties with validation, some researchers have used a simulation approach. In these simulation studies, subjects are presented through slides (e.g., Christianson, 1984; Heuer & Reisberg, 1990), videotapes-films (e.g., Clifford & Hollin, 1981; E. F. Loftus & Burns, 1982), or live stage scenarios (e.g., Leippe, Wells, & Ostrom, 1978) an emotional or a neutral event, and their memory for various information of the event is assessed either immediately or after a delayed interval. Most often, the subjects in laboratory simulations are uninformed about the forthcoming memory test.

Whereas research on real-life events shows consistently that details of emotional events are retained in memory quite well, laboratory simulation studies show more mixed results.

Several of the laboratory studies purport to show that details of emotionally arousing events are not remembered as well as details of neutral events, that is, negative emotion leads to generally worse memory (see, e.g., Barton & Warren, 1988; Clifford & Hollin, 1981; Clifford & Scott, 1978; E. F. Loftus & Burns, 1982). This view has been maintained especially within the eyewitness literature (see e.g., Deffenbacher, 1983; E. F. Loftus, 1979; E. F. Loftus & Doyle, 1987). E. F. Loftus (1980) notes the following:

Generally speaking, strongly negative and stressful emotions hinder accurate perception and memory. If a fire breaks out in a crowded theater, you will undoubtedly describe the event over and over to friends. This repeated rehearsal will improve your memory of the event itself, and perhaps also reinforce the details of your initial perception. The stress and fear that accompany such an event, however, usually result in a poorer ability to perceive accurately the details of the event and in a poorer recall ability later on. (p. 78)

In a review by Deffenbacher (1983) across 21 studies on arousal and eyewitness memory, 10 studies showed that high arousal levels increased eyewitness accuracy, whereas 11 studies showed a lower accuracy at high arousal levels. Deffenbacher resolved this inconsistency in research findings by a reclassification of the arousal levels in the various studies and then concluded that most of the studies supported the inverted-U-form relationship between arousal and memory, known as the Yerkes-Dodson (1908) law. (The Yerkes-Dodson law is discussed in further detail below.)

In a survey of experts in eyewitness psychology, Kassin et al. (1989) gathered opinions from 63 experts on 21 factors that influence the accuracy of eyewitness memory. One of these factors concerned stress and memory. The experts were asked whether they agreed with the statement, "Very high levels of stress impair the accuracy of eyewitness testimony." In response to this question, 79% of the experts agreed that the available evidence tends to favor this statement, and 71% of the experts said the statement was sufficiently reliable to offer it in court. Moreover, the majority of the experts believed that eyewitnesses have more difficulty remembering violent events than nonviolent events; only 3% had the opposite opinion. Thus, the expert consensus seems to be that emotional stress has detrimental effects on memory.

Although there seems to be an expert consensus that stress impairs memory, a body of studies have shown this relationship to be much more complex than the very general statement tested by Kassin et al. (1989). If more specific questions had been asked, for example, about memory accuracy for central detail information of emotional events, the expert consensus may have been different. The expert "consensus" may be mainly based on three frequently cited studies in the eyewitness literature: those of Clifford and Scott (1978), Clifford and Hollin (1981), and E. F. Loftus and Burns (1982). According to Deffenbacher (1983), these three studies fulfill the requirements of being studies of "forensically relevant visual memory [confirming earlier observations], namely that increases in excitement past a certain point impair witness memory" (p. 243).³

In one of these studies, Clifford and Scott (1978) compared memory of a videotaped event depicting either a violent event (physical assault on a bystander by a policeman) or a nonviolent

event (verbal exchange between the bystander and a policeman) and found that subjects who had viewed the violent version performed worse in answering a 40-item questionnaire covering both actions and physical descriptions. In the Clifford and Scott study, the critical sequence was spliced into the middle of the videotape so that earlier and later portions were identical. From the published study, however, it is unclear whether the subjects were tested on identical portions of the critical emotional event (i.e., details associated with the bystander) or if the detrimental effects were found for all details in the violent condition, including information preceding and succeeding the critical event. Without this information, the results are ambiguous.

In a subsequent article, Clifford and Hollin (1981) studied subjects' memory immediately after they had witnessed, on videotape, either a violent incident (a mugging) or a nonviolent incident (direction seeking) in which a woman and one, three, or five perpetrators could be observed. Memory performance was measured by a questionnaire that asked for detailed descriptions of the persons seen in the incident. The accuracy level was calculated from a combined score of correct recall of age, height, weight, sex, race, and clothing of either the woman (the victim) and the principal man (the perpetrator). The results revealed that the description of the principal man was more accurate in the nonviolent condition and that the accuracy of recall for the violent condition decreased with an increase in the number of perpetrators simultaneously present. However, photographic identification of the principal man was not found to be significantly different between conditions. Moreover, scores for memory of the woman, who should be regarded equally as a central character as the perpetrators in the tape, revealed that accuracy was unaffected either by violence or by the number of additional persons involved in the incident.⁴

Can one then conclude, as Clifford and Hollin (1981) do, that the presence of violence impairs accurate memory? Not uniformly. Apparently the witnesses have concentrated on the assaulted woman and the principal man. As indirect evidence of this interpretation, note that subjects in the violent condition

³ In Deffenbacher's (1983) review article, a few other studies are referred to as evidence of the detrimental effects of arousal on eyewitness memory (e.g., Buckhout, Apler, Chern, Silverberg, & Slomovits, 1974; Siegel & Loftus, 1978; Zanni & Offerman, 1978). However, in these studies, the source of the emotional arousal is dissociated from the TBR event, and it is difficult to see how "stimulation by electric shock may be the most emotionally arousing substitute available" (Deffenbacher, 1983, p. 248) and at the same time fulfill Deffenbacher's criterion of testing of forensically relevant visual memory. In general, much of the research reviewed by Deffenbacher concerns memory for events that are dissociated from the source of stress (e.g., white noise, trait anxiety, electric shocks), and obviously this type of research is far from a perfect analogue of traumatic events, in which the source of stress is the TBR event as well.

⁴ In a third study, C. Johnson and Scott (1976) showed the same complex pattern of results, that is, some measures showed better memory performance in the violent condition than in the nonviolent condition, and some measures showed worse memory performance in the violent condition. C. Johnson and Scott also found that the memory performance of male and female witnesses were differently affected by stress.

performed less well in remembering detailed information as a function of increased number of perpetrators. Given that the viewers were subjected to a state of attentional narrowing in the violent condition (cf. Easterbrook, 1959), there would be less conscious attentional resources available for each perpetrator that is added to the scene, which accordingly decreases memory for information about the victim. (The issue of attentional focusing during states of high emotional arousal will be discussed at length later on in this article.)

Consequently, the results from the studies by Clifford and his colleagues do not uniformly support the notion that details about emotional or violent events are retained less well than details about nonviolent events. In fact, there are problems in interpreting these results.

Another study commonly referred to that supports the view that emotional events are poorly retained is that of E. F. Loftus and Burns (1982). In the E. F. Loftus and Burns study, subjects were presented with either a violent or a nonviolent 2.25-min videotape of a simulated bank robbery. In the violent version, the film ended with a 15-s sequence in which a boy was shot in the head by the robber. The content of the nonviolent version was identical to that of the violent version up to the shooting episode, which was replaced with a neutral episode depicting a conversation in the bank. Memory was tested with a set of 25 multiple-choice and fill-in-the-blank questions, in which the last question was critical. The final question asked for the number on the football jersey of one of the young boys who was playing in a parking lot. This number can be considered a peripheral detail in the series of events: It was seen for a total of 2 s and from 2 to 4 s before the critical incident (i.e., the shooting incident in the violent version or the conversation in the nonviolent version). The results showed that subjects who saw the violent version remembered the TBR detail presented before the emotion-eliciting event (the number on the football jersey) less accurately than the subjects who saw the nonviolent version. However, there were nonsignificant differences between the subjects in the two conditions in testing of memory for date and time, physical characteristics of the robber, actions of the teller, details associated with the bank, and so on.⁵

Other studies have demonstrated similar detrimental effects on recall for information associated with emotional events versus neutral events (see, e.g., Christianson & Nilsson, 1984; Kramer, Buckhout, Fox, Widman, & Tusche, 1991). In these studies, color slides have been presented to subjects. In the experimental condition, traumatic autopsy slides have been embedded in the middle of the series, whereas subjects in the control condition have been presented with neutral slides in the same positions. In a subsequent recall test on the images presented, the performance in the experimental condition has been worse than that in the control condition.

From these simulations, can one conclude that all details about a highly emotional event will be less well remembered than details about a neutral event? Not really. In the results of, for example, the E. F. Loftus and Burns (1982) study, an interesting effect can be seen of impaired memory for detail information presented preceding the emotion-arousing event (cf. retrograde amnesia), that is, an impaired memory for the number on the football jersey; however, with respect to the details associated with the emotional or the neutral episode itself, there

were small differences seen between the two conditions. The average percentage of recall of all items was 80% in the violent condition (84% in the neutral condition), but only 4% of the subjects recalled the critical item. Why this difference in recall performance between the critical item and the other items? Did the detrimental effect occur because the critical item was presented immediately preceding the violent event? In the literature, similar detrimental effects for detail information preceding or succeeding the emotion-eliciting event (cf. retrograde amnesia and anterograde amnesia) have been shown in numerous other laboratory studies (Bond & Kirkpatrick, 1982; Brenner, 1973; Christianson & Nilsson, 1984; Detterman, 1975, 1976; Detterman & Ellis, 1972; Ellis, Detterman, Runcie, McCarver, & Craig, 1971; Erdelyi & Blumenthal, 1973; Fisk & Wickens, 1979; Kramer et al., 1991; Runcie & O'Bannon, 1977; Saufley & Winograd, 1970; Schultz, 1971; Tulving, 1969). Note, however, that in all of these studies, demonstrating laboratory-induced retrograde or anterograde amnesia effects, the critical emotion-eliciting event (i.e., the amnesic agent) is remembered very well and typically shows a von Restorff effect (improved memory performance on a single distinctive item embedded in the middle of a serial list, see Wallace, 1965). Furthermore, similar to clinical observations of retrograde and anterograde amnesia of functional origins (Abse, 1987; Breuer & Freud, 1895/1955; Horowitz, 1986; Kihlstrom & Evans, 1979; Kihlstrom & Hoyt, 1990; Nemiah, 1979; Schacter & Kihlstrom, 1989; Treadway, McCloskey, Gordon, & Cohen, 1992) or organic origins (Cermak, 1982; Christianson, Nilsson, & Silfvenius, 1987; Talland & Waugh, 1969; Whitty & Zangwill, 1977), recovery effects have been demonstrated for laboratory-induced amnesia (Christianson, 1984; Christianson & Nilsson, 1984; Detterman, 1975, 1976; Detterman & Ellis, 1972; see also research on arousal and memory discussed below). Note, though, that clinical observations of retrograde and anterograde amnesia indicate actual recovery effects, but the recovery or reminiscence effects in laboratory simulations usually refer to interactions between type of events and time or type of test. That is, simulation studies commonly indicate that high-arousal events are better retained than low-arousal events at delayed test intervals, or as a function of test, but they seldom show recovery of initially forgotten material.

A classic demonstration of recovery effects in laboratory research was reported by Kleinsmith and Kaplan (1963, 1964). These researchers showed an interaction between level of emotional arousal and time of test, so that high-arousal events are remembered less well than low-arousal events at short retention intervals and that memory performance for high-arousal events increases successively as a function of time elapsed between study and test. These results contradict the typical forgetting curve (Murdoch, 1974) and what would be predicted for high-arousal events according to the Yerkes-Dodson (1908) law. The specific interaction presented by Kleinsmith and Kaplan (1963, 1964) has been replicated in a few other studies using different experimental designs (see Butter, 1970; Howarth &

⁵ A significant effect was found, however, by sign test across items (14 out of 16 items were remembered worse in the emotional condition).

Eysenck, 1968; Kaplan & Kaplan, 1969; Levonian, 1967; McLean, 1969; Osborne, 1972; Walker & Tarte, 1963, see also studies specific to repression presented later). Still, Kleinsmith and Kaplan's pattern of results, that memory for high-arousal events increases over time, has to be considered a rather spectacular finding in the memory literature. On the other hand, their demonstration that high-arousal events are retained better than low-arousal events at delayed retention intervals has been frequently replicated in subsequent studies. Ample studies have shown that high-arousal events are remembered at about the same level as low-arousal events at short retention intervals but that a superior memory performance for high-arousal events over low-arousal events is obtained at delayed test intervals (see Archer & Margolin, 1970; Berlyne, Borsa, Hamacher, & Koenig, 1966; Burke et al., 1992; Christianson, 1984; Corteen, 1969; Farley, 1973; Folkard & Monk, 1980; Kaplan & Kaplan, 1969; Maltzman, Kantor, & Langdon, 1966; Sampson, 1969; Schwartz, 1974; Uehling & Sprinkle, 1968, see also Craik & Blankstein, 1975, and Eysenck, 1976, 1982, for reviews).

Although some of the eyewitness studies listed above, as well as various other laboratory analogues, constitute interesting simulations of retrograde and anterograde aspects of memory seen in real-life situations, they do not show memory impairment for the emotionally arousing event itself. Thus, it can be concluded that memory for some information, for example, details presented preceding and succeeding an emotional event, seem to be impaired, at least temporarily. But, one cannot conclude that memory for details about the emotional event per se is impaired. On the contrary, the results of eyewitness studies and studies on emotional arousal and memory are consistent with findings from field studies (e.g., Yuille & Cutshall, 1986), autobiographical studies (e.g., Wagenaar & Groeneweg, 1990), and flashbulb studies (e.g., Brown & Kulik, 1977) in showing that emotionally arousing events are relatively well retained in memory over time. This specific outcome is pertinent to the ongoing discussion about how reliable eyewitnesses are in their recollections of emotional events. Because there is less loss in retention of emotional events than of nonemotional events and because eyewitnesses in police investigations and court settings are more likely to be interviewed and questioned after an extended interval (several weeks or months after an accident or a crime), it would be more appropriate to conclude that the presence of emotional reactions will increase the witnesses' reliability rather than decrease it, as is commonly claimed in the eyewitness literature.

Besides the Type of Event (emotional vs. neutral) $\times$ Time of Test (immediate vs. delayed) interaction, some of the studies indicate a Type of Event $\times$ Type of Detail Information (central vs. peripheral) interaction. That is, emotional events seem to be well retained with respect to the emotional event itself and the central detail information of the emotion-eliciting event, but peripheral information within an emotional scenario is less well retained. In the next section of this article, I discuss studies that have specifically compared memory for central and peripheral details in emotional versus neutral events.

Central Versus Peripheral Details

In a series of recent laboratory studies on emotion and memory, a typical pattern has emerged: Central details are retained

better than corresponding details in nonemotional events, whereas the reverse pattern is seen for peripheral details (e.g., Burke et al. 1992; Christianson, 1984; Christianson & Loftus, 1987, 1991). Before discussing these studies, it is important to define here what is meant by central and peripheral emotional detail information. First, note that it is difficult to determine what is central and what is peripheral information in advance, especially outside the laboratory. Laboratory studies have, however, an advantage over real-life situations because normative data can be collected to assist in the definition of centrality of detail. Second, note also that the issue of centrality, as well as the definition of associated information (preceding and succeeding events), is a question of continuum and not absolute distinctions. In the present article, central and peripheral details are distinguished as differentially remembered detail information within an emotional scenario. Thus, the statements here about memory for central and peripheral emotional information refer to a distinction between information that is connected with the source of the emotional arousal (i.e., the gist of the event and its central details) and information that is irrelevant or spatially peripheral to the source of the emotional arousal (peripheral details).⁶

In a study by Christianson (1984), subjects viewed a slide sequence depicting two different versions of the same type of event. Both versions began by showing a mother and son walking through a downtown area. In the middle section, the emotional version shows the boy being hit by a car, then lying on its hood bleeding heavily from an eye injury, and then being transported to a hospital where the mother leaves him for care. The middle section in the neutral version shows the boy passing the same car, going to school in a taxi, and the mother leaving her son at school. Both versions end by showing the mother on her way back home. In this study, it was found that subjects who had watched the emotional version of the slide sequence recalled the main features and the theme of the pictures better than subjects who watched the neutral version. However, when subjects were given a recognition test in which the main features of each picture were held constant and only the peripheral, surrounding, information was varied, no difference was obtained between groups.

In a subsequent study by Christianson and Loftus (1987) using the same type of stimulus material, the subjects were instructed to select and write down the most distinguishing detail of each slide and were then tested for recall of these details, as well as of the pictures themselves. It was found that subjects were better able to recall central features selected from emotional pictures; however, they were less able to recognize the specific pictures that they had seen. This pattern of results was obtained both after short (20 min) and delayed (2 weeks) retention intervals. Furthermore, when the subjects were contacted by telephone 6 months later, 89% of the subjects who had seen the emotional slide sequence could recall the central features

⁶ The implication of this distinction is that emotional arousal is defined on the basis of the scenario. However, although central details most often are emotionally valenced material, it is not justified to assume that peripheral details are always emotional material just because they occur within an emotional scenario.

that captured the theme of the emotional event. Of the subjects who had seen the neutral version, 52% could remember its essence.

Kebeck and Lohaus (1986) showed subjects either an emotional or a nonemotional version of a film depicting an argument between a teacher and a student. The results showed that subjects in the two conditions were equal in recall of central details of the film; however, subjects who had seen the emotional version were less able to remember peripheral information.

Also using a simulation approach, Heuer and Reisberg (1990) presented subjects with a series of slides depicting either a neutral or an emotional version of a story in which a mother and her son visit the father at his workplace. The neutral version shows the father as a garage mechanic fixing a car; the emotional version shows the father as a surgeon operating on a victim of an accident. The subjects were tested after a 2-week interval by means of a recognition test that included questions about information central to each slide (information pertaining to the basic story) or about peripheral details (specific details in a particular slide). The results replicated earlier findings in showing that subjects presented with the emotional version of the story remembered more of the central information than subjects who saw the neutral version. But the Heuer and Reisberg study also showed that the peripheral details were better retained in the emotional condition.

In a follow-up study by Burke et al. (1992), a closer investigation was made with respect to memory for central and peripheral detail over time (immediate testing vs. testing after one week). Using the same stimulus slides as did Heuer and Reisberg (1990), Burke et al. found that detail information that was spatially and temporally associated with the central characters in the slides (also the gist of the event) was better retained in the emotional condition than in the neutral condition. This pattern of results has been shown before, but what is more important is the beneficial effects for emotional detail information over time. That is, the favorable effects for central details that were obtained at immediate testing increased as compared with the neutral condition at delayed testing (i.e., after 1 week). Furthermore, the disadvantage for the peripheral details in the emotional condition decreased at delayed testing. Thus, the Burke et al. study suggests not only that is central detail information better retained in emotional events but also that detail information in general seems to be more resistant to forgetting in emotional events than in neutral events over time. (Related findings from a series of unpublished studies are reviewed by Heuer & Reisberg, 1992.)

It can, of course, be argued that people remember details from emotional events differently than details from neutral events because of inadequate equating of the detail information of the emotional and the neutral events. For example, the depiction of emotional events often differs from that of neutral events in more than the presumed elements (e.g., the complexity of the scene, the centrality of the TBR information, the background information). Christianson and Loftus (1991) addressed this issue in a study in which subjects were presented with a thematic series of slides where the emotional valence of one critical slide in the series was varied, although the TBR details were identical in the emotional and the neutral versions

of this critical slide. In a neutral version, the critical slide showed a woman riding a bicycle. In an emotional version, the same woman was seen lying injured on the street near the bicycle. In both versions, a peripheral car was seen in the distant background. The results from a series of five experiments with this stimulus material demonstrated that the central detail information (detail information about the woman) was retained better in the emotional condition but that the peripheral detail information (detail information about the car in the background) was retained better from the neutral condition.

Also pertinent to the issue of memory for central and peripheral information in emotional versus neutral events is research related to the phenomenon of "weapon focusing" (see e.g., Cutler, Penrod, & Martens, 1987; Kramer, Buckhout, & Eugenio, 1990; E. F. Loftus, Loftus, & Messo, 1987; Maass & Köhnken, 1989; Tooley, Brigham, Maass, & Bothwell, 1987). Studies on weapon focusing normally demonstrate that certain critical stressful objects, like a gun or a knife being used in a crime, can capture people's attention and thus promote memory for the weapon, but at the expense of other details in memory (compare, however, Deffenbacher, 1983; Leippe et al., 1978; Sussman & Sugerman, 1972).

Experiments in which subjects' eye movements have been monitored while they view complex scenes (G. R. Loftus & Mackworth, 1978) have shown that people fixate faster, more often, and for longer durations on unusual or highly informative objects like weapons. In a study by E. F. Loftus, Loftus, and Messo (1987), eye movements were monitored while subjects were presented with one of two versions of a story that began with a customer going through a cafeteria line in a fast-food restaurant. In the weapon version, the customer pointed a gun at the cashier, who handed over some money. In the nonweapon-nonviolent version, the customer handed the cashier a check, and the cashier returned some money. Except for the gun/check episodes, the two events were identical. The results indicated that subjects fixated on the weapon more and longer than on the check. It was also found that subjects in the weapon condition had poorer memory for circumstantial details of the event, for example, the appearance of the customer. No measure was used, however, on the critical central object, the weapon or the check. The same findings have been reported by Kramer, Buckhout, and Eugenio (1990), who found that subjects who were presented with a slide sequence including a weapon remembered fewer details about the person holding the weapon than subjects who saw a comparable sequence without a weapon (cf. Tooley et al., 1987).⁷ Two studies, that by Cutler et

⁷ A similar effect was demonstrated by Peters (1988) in a real-life study at an immunization clinic. Peters found that people were less able to provide an accurate physical description of and to identify a person who had recently inoculated them than a second person they had met immediately after getting their shot. This study should, however, be interpreted cautiously because of problems with order effects and other confounding factors. Furthermore, in a similar study on children having a blood test, G. S. Goodman, Hepps, and Reed (1986) found no detrimental effects on identification of the technician who had the children's blood drawn. G. S. Goodman, Hepps, and Reed found that the more highly stressed children remembered central detail information better than the control children, whereas the control children remembered the peripheral detail information better than

al. (1987) and that by Maass and Köhnken (1989), show some support for weapon focus, but not that emotional arousal per se impairs memory.

A common interpretation of this type of finding is that almost all attentional resources are allocated to the central feature of the threatening event (e.g., a gun) and limited resources are left over to encode surrounding information (cf. the resource allocation theory by Ellis & Ashbrook, 1988). In a real-life situation, the direction of a weapon may be a matter of life and death, and it thus seems logical to think that attention will go where the weapon is and to what it points to. The role of attention as a critical factor in explaining weapon focus findings and interactions between type of events and type of detail information will be discussed in further detail later in this article.

Retrieval of Emotional Events

In addition to aspects of attentional selectivity and associated limitations in retaining a wide variety of details from emotional events, the accessibility of properly stored information constitutes a critical aspect in memory for emotional events. Research by Robinson (1980) indicates that memories of personal experiences associated with very intense feelings (irrespective of the pleasant or unpleasant quality of these feelings) are more accessible than those associated with mildly intense feelings (see also Brewer, 1988, for comparable findings). Robinson's (1980) study examined differences in memory accessibility, as indexed by report latency (subjects reported the first specific experience that came to mind for a series of prompt words) and not probability of recall (or forgetting). Other research (Christianson & Nilsson, 1984; P. J. Davis, 1987, 1990; Wagenaar, 1986) has found that negative emotional events are less accessible than neutral events when subjects have been tested with a limited amount of retrieval information, as in free recall. On the other hand, when the subjects in these studies have been provided with different types of retrieval cues, the difference in memory performance between emotional and neutral events has disappeared. For example, in a study by Christianson and Nilsson (1984), a memory impairment was demonstrated for verbal TBR information presented along with traumatic pictures (grotesque forensic pathology photographs of facial injuries), as well as for TBR information succeeding these horrible pictures (i.e., demonstrating an anterograde amnesia). When memory for the TBR information was tested in a subsequent recognition test, the anterograde amnesia effect receded completely. The same retrieval effect was found in a study by Christianson and Larsson (1990) when the associated verbal information was tested by means of stem completion and fragment completion (cf. testing of implicit memory; see Graf & Schacter, 1985; Schacter, 1987).

Internal and external context effects. Several studies on context effects have shown that people's ability to remember a certain event is enhanced if the internal context (e.g., a certain

mood state) in which the person perceived the initial event is reinstated at the time of retrieval (see Blaney, 1986; Bower, 1981; Bower, Monterio, & Gilligan, 1978; Clark, Milberg, & Ross, 1983; Eich, 1980). Note, though, that because of several failures to replicate mood-dependent retrieval effects (Bower & Mayer, 1985, 1989), Gordon Bower has concluded that this is probably a small and unreliable effect. To come to grips with the inconsistency in research findings, Bower has taken a different approach by postulating a causal belonging hypothesis (Bower, 1987). According to this hypothesis, the failure arises because mood has been induced externally as a background, that is, before the TBR items are presented. Bower (1987) notes the following: "On this hypothesis, contiguity alone between the emotion and the event would not be sufficient to produce an association; rather, the S must perceive the emotion as causally belonging to the event or the materials which give rise to it," (p. 451). According to the same hypothesis, "autobiographical memories should show mood-dependent retrieval because these are events that naturally caused the S to feel a pleasant or unpleasant emotion" (p. 453). This reasoning parallels one point outlined in this article, namely, that details of emotional events will be remembered quite well when the emotional arousal is evoked by the TBR event rather than being evoked by a source that is causally unrelated to the TBR event. Thus, a state of increased emotional arousal is significant as an intervening variable in explaining memory impairments (or enhancements) only when the emotional reaction is an inherent property of the TBR event.

Unfortunately, in real-life situations, the internal and external context at the time of recollection is typically very different from the internal state and the external circumstances that were present when the person originally experienced the event. This discrepancy between learning and retrieval conditions is, of course, more significant for emotional events than neutral events and, thus, makes retrieval of emotional memories more intricate. However, when the internal and the external contexts are reinstated for autobiographical memories, the improvement in memory for emotional events has proved to be very successful (see Bower, 1987; see also Christianson & Nilsson, 1989, for a case study of traumatic amnesia).

Repression studies. Pertinent to a discussion of retrieval and context effects are studies related to the repression hypothesis, that is, studies on motivated forgetting and recovery of previously inaccessible traumatic events. According to the Freudian repression hypothesis, unpleasant emotional or traumatic events are repressed from a conscious state by the person to avoid and to cope with an overwhelming psychological pain (see Breuer & Freud, 1895/1955; Erdelyi, 1990; Erdelyi & Goldberg, 1979; Freud, 1915/1957; MacKinnon & Dukes, 1962; Singer, 1990). Excessive stimulation is hereby seen as the inciting cause of the repressive state. This view suggests that emotional events are properly registered and retained but cannot be recalled until associations or ideas make contact with the emotional response appropriate to the repressed information.

There have been a number of attempts to experimentally induce so-called repressive processes in laboratory settings to investigate their effects on memory for unpleasant events (Erdelyi, 1970; Flavell, 1955; Glucksberg & King, 1967; Jung, 1906/1972; Levinger & Clark, 1961; Polans, 1985; Zeller, 1950a,

the highly stressed children. This is the same pattern of data that has been shown in a series of laboratory studies (Burke, Hever, & Reisberg, 1992; Christianson, 1984; Christianson & Loftus, 1987, 1991; Christianson, Loftus, Hoffman, & Loftus, 1991).

1950b, 1951). Although the relevance of this research to repression is controversial (see Erdelyi & Goldberg, 1979; Holmes, 1974), the results from some of the studies demonstrate (a) that events associated with unpleasant or emotionally arousing feelings are remembered less than neutral events at short retention intervals and (b) that unpleasant events are better remembered at a delayed test than at an immediate test (Erdelyi, 1970; Flavell, 1955; Glucksberg & King, 1967; Levinger & Clark, 1961; Zeller, 1950a). From Freud's, or a psychoanalytical, point of view, these results indicate that there is a desire to exclude threatening, anxiety-provoking memories from consciousness to avoid emotional confrontation. However, over time, the unpleasant events will be less threatening and, thus, will become more accessible for conscious remembering. Although the repression interpretation is, to some degree, reasonable, there are several alternative interpretations of the type of findings described in these studies (see e.g., Bower, 1990; Holmes, 1974, 1990; Horowitz, 1979; Rapaport, 1942; Walker, 1958, 1967).

Hypermnesia. Also pertinent to retrieval, or recovery, effects is the finding of *hypermnesia*, which refers to the phenomenon in which recall of previously unreported events sometimes exceeds the forgetting of previously recalled events (P. J. Davis, 1990; Payne, 1987; Roediger & Challis, 1989; Scrivner & Safer, 1988). Note that although some researchers (e.g., Eysenck, 1976, 1982) interpret reminiscence effects in single-study paradigms as because of arousal at the time of encoding, hypermnesia effects in multiple-test paradigms are not specifically related to emotion or arousal. However, there are a few studies on hypermnesia that do relate to emotion and memory. For example, in a study by Scrivner and Safer, subjects watched a videotape that portrayed a burglar breaking into a house and shooting three people. Subjects were tested for detail memory about the violent event in four consecutive recall tests within 48 hours. The Scrivner and Safer study showed that subjects became more accurate over tests for details presented preceding, during, and succeeding the violent event, and the authors concluded, "the apparent amnesia for some details on the initial recall trial represented temporary, not permanent, failures of memory." (Scrivner & Safer, 1988, p. 375). Similarly, P. J. Davis (1990) reports hypermnesia effects for negative emotional experiences, especially in people who initially recalled very few negative emotional memories. She concludes that the overall pattern of results observed in her studies (mainly concerning repression) indicates that an initial difficulty in remembering certain kinds of negative emotional experiences reflects a limited accessibility rather than a limited availability to these experiences.

Taken together, the studies in which the amount of retrieval information has been varied, the studies on context effects, the studies on hypermnesia, and the studies related to the repression hypothesis suggest that great consideration should be given to differences in situational demands when the person has to retrieve emotional information.

Emotional Arousal in Laboratory Versus Real-Life Events

Is the degree of arousal or stress so different in actual traumatic events that the effects of stress on memory from laboratory studies cannot be generalized to real-life situations? In his

review of arousal and eyewitness memory, Deffenbacher (1983) states that the stress and arousal experienced by a witness in an actual crime situation is usually beyond the optimal level of arousal and that memory is therefore impaired in these situations. According to Yuille and Tollestrup (1992), the witnesses in laboratory research are essentially uninvolved bystanders who rarely feel personal threat of the magnitude that a victim or witness to an actual crime like a robbery is likely to feel, and thus, the memory performance of laboratory witnesses follows a different pattern than that of real-life witnesses.

Certainly, some laboratory simulations seem pallid in comparison with assassinations and accidents. Does this mean that one cannot learn about emotional memories from laboratory simulations of traumatic events? Or are memories in these two settings qualitatively different?

Of course, one obstacle to laboratory simulation studies of memories for traumatic events is that researchers are ethically constrained from inducing emotional stress by deceiving research subjects simply to test their performance. There are ethical guidelines for studies involving human subjects that prohibit researches from using procedures that cause psychological harm (American Psychological Association, 1990). Inducing strong emotions in an experimental situation in which subjects sometimes are frightened or distressed must obviously be done with great caution, and most experimental studies must be approved by review committees to ensure compliance with professional and ethical guidelines. This limitation does not mean that realistic simulations within the guidelines cannot be devised. In some instances, people are genuinely aroused, and even frightened, when they view simulated events; horror film makers have known this for decades. A variety of different procedures have succeeded in inducing a range of emotional responses in laboratory situations in a manner that has been ethically approved (e.g., exposing people to loud noise, giving people an electric shock, staging crimes of a fairly emotionally arousing nature, having people view slides or films of bloody accidents and crimes). In short, the simulation studies can succeed in producing an emotional impact, permitting a researcher to examine its consequences, and thus do provide useful and also comparable information about traumatic events.

A few studies have compared eyewitness memory in actual victims of crimes with that of nonvictim bystanders (Hosch & Cooper, 1982; Hosch et al., 1984). For example, Hosch and Cooper (1982) examined whether a theft victim was more attentive than a nonvictim witness to a theft. It was hypothesized that victim witnesses would recall more details about the thief than bystander witnesses and that as a consequence, their accuracy of recall and confidence in the identification made would exceed those of bystander witnesses. They found no significant differences in accuracy or confidence of victims compared with bystanders. In a subsequent study by Hosch et al., subjects were either nonvictim witnesses or victim witnesses of a staged theft. After the theft, all witnesses were required to provide statements to campus detectives and to make an identification of the thief from a photo montage. Once again, there were no statistically significant differences between the accuracy rate of victims versus bystanders, although the mean accuracy of victims was less than that of bystanders (37% vs. 52%). Hosch and

Bothwell (1990) also conducted a study in which the arousal level of victims and bystanders were measured. It was found that victims were not differently aroused nor more accurate in identification than bystanders. However, the victims' descriptions of the perpetrator were more accurate than those given by the bystanders.

Furthermore, corresponding levels of memory performance for similar detail information can be seen between studies of real-life traumatic events and laboratory simulations of emotional events. In the field study by Yuille and Cutshall (1986), the accuracy of memory for colors of clothing of the central character was quite high and varied between 66% and 83%. This is just about the same level of recall performance for color of clothing that was demonstrated in a laboratory study by Christianson and Loftus (1991). In the experiments conducted by Christianson and Loftus (1991), it was found that 66% to 73% of the subjects who had viewed an emotional event (a woman lying injured on the ground) correctly recalled the color of the woman's coat. (The corresponding proportion of correct recall for the neutral event, the same woman riding a bicycle, was 25% to 27%). Although it is probably coincidental that the figures for color information were very close in these two studies, the results indicate that memory performance for detail information in emotional events is relatively high in both real-life and laboratory-induced emotional events.

These empirical findings remedy to some extent the criticism that real victims/witnesses react differently from bystanders emotionally or that laboratory findings cannot be extended to real-life experiences (see e.g., Neisser, 1978; Yuille & Cutshall, 1989; Yuille & Tollestrup, 1992).

To what extent then does a state of high emotional arousal per se mediate the effects reviewed so far? According to the eyewitness literature (e.g., Deffenbacher, 1983; E. F. Loftus, 1979), high levels of stress or arousal experienced by witnesses impair accuracy of memory, and this conforms to the Yerkes-Dodson (1908) law. Although this classic theory has never been sufficiently developed to account for the relation between emotional stress and eyewitness memory, it is by far the most frequently cited in this context. It is therefore important to consider the basic assumptions behind this law and to discuss to what extent the Yerkes and Dodson hypothesis is supported by current research findings on memory for stressful events.

Emotional Arousal, Memory, and the Yerkes-Dodson Law

It has long been assumed that arousal and cognitive efficiency are strongly interrelated. An early attempt to generalize this relationship was provided by Yerkes and Dodson (1908), who proposed an inverted-U-form relation between tension-arousal and performance. It is assumed that an increase of arousal from very low levels to moderate levels causes more cognitive resources to be available and increases the rate of mental and response operations.⁸ However, if the arousal level exceeds a hypothetical optimal point on the arousal continuum, mental efficiency begins to decline. Numerous reports in the literature (e.g., Deffenbacher, 1983; Eysenck, 1982; Kahneman, 1973; E. F. Loftus, 1979; E. F. Loftus & Doyle, 1987; Mandler, 1975) advocate that this reasoning can be applied to

the relationship between emotional arousal and effectiveness of perception and memory as well. That is, moderate levels of emotional arousal are assumed to facilitate learning and memory performance; successive increases of emotional arousal beyond the optimal arousal level are correlated with successively lower degrees of learning and memory (see Figure 1).

Although the Yerkes-Dodson (1908) theory is commonly adopted in psychology textbooks to account for the findings obtained in studies of emotional arousal and memory, a look into emotion-and-memory research reveals that this view is not very often supported by contemporary research findings. Moreover, many questions arise when one looks more closely at the basic assumptions underlying this theory. It is beyond the scope of this article to review all the types of manipulations used in experimental arousal-performance research that are pertinent to the Yerkes-Dodson law. So, the discussion of the Yerkes-Dodson law in this article concerns the validity of this law in describing the relationship between emotional arousal (stress) and memory and its relevance for eyewitness memory in particular.

Before considering some of the empirical evidence that has been referred to in support of the specific shape of the curve, I first discuss the very basic assumption of a unidimensional continuum of arousal that is hypothesized in the Yerkes-Dodson (1908) law. One must then ask: What kind of arousal is referred to in this function?

Past difficulties with constructs like fear or anxiety made the concept of arousal popular in the psychological literature largely because it seemed to offer a quantifiable equivalent to various states of high emotion (Neiss, 1988). From a behavioral point of view, arousal (activation, excitation) has often been conceived as an intensity dimension, ranging from the physiological state of coma or deep sleep to that related to intense emotions and excitement or, put into psychiatric terms, from somnambulism to states of panic. Whereas many researchers have treated arousal as a unidimensional concept, assuming that a heightened autonomic arousal corresponds to a concomitant increase in the level of cortical arousal (see e.g., Duffy, 1967; Hebb, 1955; Malmö, 1959), others have questioned the construct of global, or generalized arousal and have proposed several different forms of arousal (see Lacey, 1967; Näätänen, 1973; see also Neiss, 1988, for a review). According to Lacey (1967), arousal processes should be separated into at least three different forms: electrocortical arousal, as measured by electroencephalography or evoked cortical response; autonomic arousal, defined by means of different peripheral measurements (e.g., heart rate, electrodermal activity, and pupillary responses); and behavioral responses, defined in terms of subjective performance. Dissociations have been pointed out both between and within these categories of arousal (Lacey, 1967). So, what arousal index is referred to in the Yerkes-Dodson (1908) law?

From a neurophysiological point of view, one can also distinguish between at least two arousal systems. One is the reticular activation system (RAS), which is considered to be important

⁸ Yerkes and Dodson (1908) also made a distinction between easy and difficult tasks in that they found an improvement in performance of easy tasks at high arousal levels.

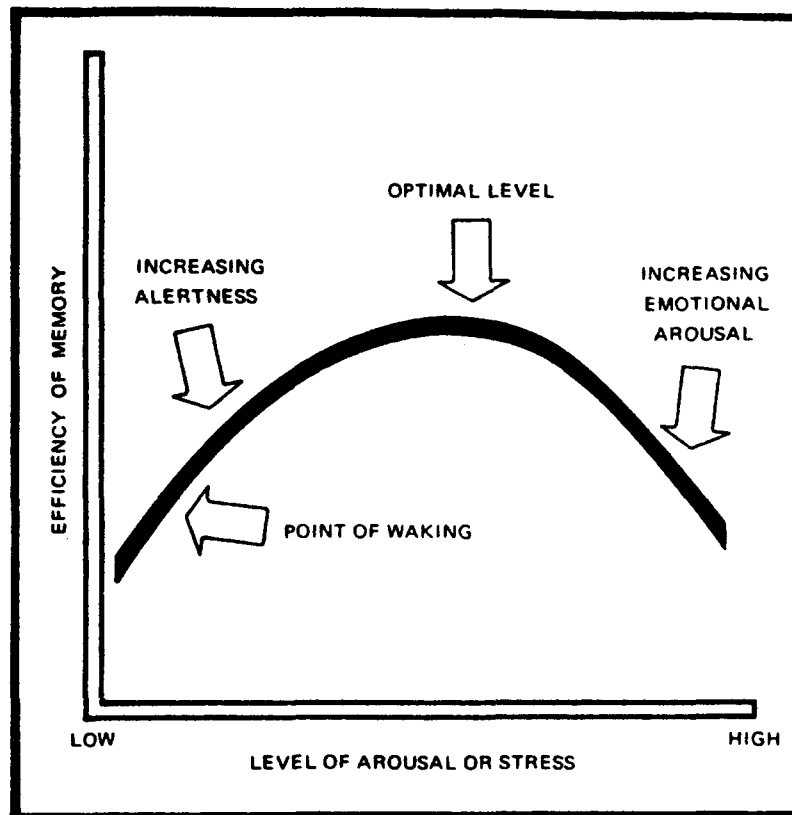


Figure 1. The Yerkes-Dodson (1908) law and the relationship between memory performance and level of arousal or stress according to E. F. Loftus (1980). (From *Memory* [p. 79] by E. F. Loftus, 1980, Reading, MA: Addison-Wesley. Copyright 1980 by Elizabeth F. Loftus. Reprinted by permission.)

as an integrative and modulating system of arousal (Luria, 1981). The RAS receives information from all sensory systems and is connected to the cerebral cortex by ascending and descending pathways. The lower part of RAS is assumed to be sensitive to the overall level of arousal or activation (i.e., tonic arousal changes), and the upper part is assumed to be more sensitive to transient changes (i.e., phasic arousal changes) and thus alerts the organism to different situational demands (Lindsley, 1957). Another activation system, specific with respect to emotional arousal, has been localized to different neural pathways in the area of the hypothalamus (the medial forebrain bundle system) and of the limbic system (the amygdala and the hippocampus). By means of various techniques, such as depth-electrode stimulation, drug injection, and lesion studies, these subcortical structures have been found to be very critical for the modulation of emotions or emotional tone and, thus, have been shown to affect the arousal level of the organism (see Papez, 1937; Routtenberg, 1968; Watson, 1981). Several neuropsychological studies have shown arousal differences both within and between hemispheres (see Neiss, 1988, for a review).

In considering these various arousal systems and dissociations between different forms of arousal, it is obvious that there is no unitary conception of arousal and, hence, no real grounds for postulating a single dimension of arousal. Rather, it seems

more reasonable to assume that different arousal-activation systems are involved for different portions of the Yerkes-Dodson (1908) curve, for example, that RAS is associated with changes from sleep to alertness (i.e., the left part of the curve) and that limbic structures are involved in different states of emotional involvement (i.e., the right part of the curve). The idea of more than one arousal system to account for different parts of the inverted-U-shaped relationship between arousal and performance has also been proposed by Broadbent (1971).

What evidence within memory-and-emotion-arousal research has been provided to support the specific shape of the Yerkes-Dodson (1908) curve? In the original study by Yerkes and Dodson, the data provided was based on animal-learning studies, for example, studies of rats in an electrical-shock-and-maze-learning task. The evidence for this curve from human studies is, however, less convincing. Whereas the initial rise of performance level corresponding to the left part of the inverted-U curve is considered to be a valid phenomenon (i.e., that an increase in memory performance takes place from a state of sleep or, on waking up in the morning, to a state of alertness), it is much less clear whether a general decrease in memory performance occurs with increasing emotional arousal beyond the optimal level of the inverted-U-shaped curve. In reviewing the data that claimed to support the Yerkes-Dodson law, Näätänen (1973) concluded that "the down turn

curve after the 'optimal level of activation' is an artifact of relatively uncontrolled behavioral direction, as well as of the ecological unrepresentativeness of such experiments" (p. 155). Commonly, studies on the relationship between arousal and performance use a second task to vary arousal and, according to Näätänen (1973), the inverted-U relationship obtained under such experimental conditions is understood to be an artifact. That is, as the demands of the second task increase, the direction of behavior is diverted away from the task of primary interest. When performance is measured under states differing from each other only with respect to the intensity of physiological changes, there is no direct connection between arousal level and task performance. Näätänen (1973) notes the following: "It might be possible under certain experimental conditions to induce an EEG showing an extreme degree of activation even in a subject whose behavior could be characterized as especially efficient, having only one direction, that of the experimental task" (p. 171).

Thus, if diverse arousal agents that do not belong to the TBR event are used to vary emotional arousal, it is highly likely that the specific effects of such stimulation, when intense, produce the data supporting the Yerkes-Dodson (1908) curve. So, for example, extraneous sources of arousal like loud noise, failure stress, worry about a threatening experimental situation, and so on are likely to make a person nervous and emotional and will accordingly distract him or her from the TBR information. If the emotionally arousing agent is related to the TBR event and if one is not distracted by an extraneous source of arousal that is stronger in intensity than the TBR event, there is no evidence that high arousal impairs memory performance.

In a close examination of the empirical evidence relating arousal and performance, Neiss (1988) provides further evidence against a unitary conception of arousal and concludes that the proposition of an inverted-U relationship between arousal and performance is supported only in a weak and psychologically trivial fashion.

To date, there is no single study in the eyewitness literature—at least not to my knowledge—that includes multiple events that differ in degree of emotional arousal, and in which memory has been compared for these emotion-eliciting TBR events, and that supports the inverted-U relationship. In fact, most studies include only two levels of emotional arousal: a low or moderate level of arousal (often concomitant to a neutral event) and a high level of arousal (concomitant to an emotional event). In experimental research, it is evidently methodologically difficult to induce emotional arousal over a wide range of a hypothetical arousal continuum because ethical considerations associated with emotion-and-memory research prevent us from subjecting people to very high levels of emotional arousal by means of traumatizing stimuli. In field research, ethical guidelines likewise make it difficult for researchers to study victims' memory performance in the midst of a traumatic experience. An opposing argument from spokesmen for the inverted-U relationship could be that even if there are only two levels of arousal, and given that high arousal leads to bad performance, a reasonable inference is that even higher level arousal would lead to even worse performance. A counterargument is then that if one looks at the literature on memory for traumatic events in real-life settings, one does not see a very low memory

performance at extreme levels of negative arousal. Rather, as shown by Yuille and Cutshall (1986), Christianson and Hübner (in press), and Wagenaar and Groeneweg (1990), some critical information is retained quite well. This is also true in rape cases (e.g., Christianson & Nilsson, 1989) in which the victim shows an initial amnesia for the traumatic event but eventually recovers and remembers the assaulting episode in great detail.

Another dilemma is that all the studies at hand suffer from the inability to specify absolute levels of arousal: Normally the subjective judgment of the experimenter decides what is the functional stress level in a particular study. As pointed out by Neiss (1988) and McCloskey and Egeth (1983), findings that seem to refute the inverted-U hypothesis can be explained away by claiming that subjects were insufficiently aroused, or too aroused, or that the task was too complex or too simple for any of the experimental arousal levels. In Deffenbacher's (1983) review of research concerning the effects of arousal on the accuracy of eyewitness memory, he adopted various studies to the inverted-U-form curve by assuming that studies showing increased memory performance under stress involve stress levels below the point of optimal stress, whereas studies showing impaired memory performance involve stress above the optimal level. This means, in principle, that all studies fit the Yerkes-Dodson (1908) law and the inverted-U hypothesis is therefore nonfalsifiable, or as put by Neiss (1988), "immunized against falsification" (p. 355). In a recent talk by Egeth (1990) on research on the effects of stress and memory performance, he stated that no clear pattern emerges: Sometimes no effects are obtained, sometimes there are positive effects, and sometimes there are negative effects of stress on memory. (See also McCloskey & Egeth, 1983, for a further discussion of the use of the Yerkes-Dodson law in expert psychological testimony)

Conclusions About the Yerkes-Dodson Law: Time for Retirement?

Considering (a) the absence of a unitary index and absolute levels of arousal or emotional arousal, (b) the variation in emotional reactions obtained in different study situations, (c) ethical restrictions, and (d) the diversity in empirical findings, it is very difficult to compare and evaluate effects of different levels of arousal (along a unidimensional continuum) on memory performance. Besides, there is a lack of empirical evidence supporting the specific inverted U-form function between degree of emotional arousal and memory. Rather than showing an impaired memory performance at states of high levels of emotional arousal, as would be predicted from the Yerkes-Dodson (1908) function and arousal-level theorists, recent research findings from field studies and laboratory simulations suggest that people retain detail information from highly emotionally arousing events quite well. This is a very consistent finding at prolonged test intervals (Bohannon, 1988, 1992; Burke et al., 1992; Heuer & Reisberg, 1990; Levonian, 1967; Pillemer, 1984; Rubin & Kozin, 1984; Wagenaar & Groeneweg, 1990), and especially for central detail information (Burke et al., 1992; Christianson, 1984; Christianson & Loftus, 1987; G. S. Goodman et al., 1986). With a lack of objective measures and relevant indexes of different states of emotional arousal, serious doubts can be raised

about the applicability of the Yerkes-Dodson law as a causal interpretation of the relationship between emotion and eyewitness memory. Thus, I agree with Neiss's (1988) objection to a global construct of arousal as an equivalent to various emotional states, and I agree with Egeth (1990) in that it is an oversimplification to try to account for memory behavior in terms of a single concept such as arousal without considering other cognitive and emotional factors. In my opinion, the Yerkes-Dodson law has served out its role in psychology and is no longer needed as a general description in relating emotion and memory in the eyewitness literature. (For a further discussion of the inverted-U hypothesis, see Anderson, 1990, and Neiss, 1988, 1990).

The Easterbrook Hypothesis

Easterbrook's (1959) cue-utilization hypothesis is commonly used to account for the U-form relationship between arousal and processing efficiency described by Yerkes and Dodson (1908). According to Easterbrook's theory, there is a progressive restriction of the range of cues used or attended to as a function of an increase in emotional arousal. At states of moderate arousal, this restriction in cue utilization is assumed to benefit performance because relevant information is supposed to be attended to and irrelevant cues are excluded. However, a further increase in emotion, corresponding to high stress or anxiety, would imply a reduction of cues that would also include relevant information (see also Bacon, 1974; Baddeley, 1972; Korchin, 1964; Mueller, 1979; Wachtel, 1967, 1968). Easterbrook's view has been extended by Mandler (1975), who suggested that attention-demanding characteristics of the autonomic nervous system arousal are the critical components that relate emotional arousal to restricted cue utilization. Mandler states the following:

Given the limited capacity of attention-consciousness and the presence of additional events that make demands on that limited capacity, it is not surprising that with increasing arousal the number of other events (cues) that can share conscious attention will be decreased. (Mandler, 1975, p. 124)

In situations in which the arousal of the sympathetic nervous system or emotional arousal becomes very intense, "it floods attentional mechanisms and decreases the amount of information that the organism can recruit effectively either from the environment or from its own memory store" (Mandler, 1975, p. 123). This point of view is furthered by Eysenck (1982), who suggests that high arousal leads to a reduced ability to engage in parallel or shared processing, because a "smaller proportion of attentional capacity is available for task processing" (Eysenck, 1982, p. 176).

According to E. F. Loftus (1980), high states of emotional arousal hinder memory because highly emotionally aroused subjects do not pay adequate attention to important cues in the environment and, therefore, exclude information crucial for accurate memory of the emotional event. E. F. Loftus (1980) refers, for instance, to a study in which army parachutists were asked to perform a mental task before jumping:

The anxiety of the impending jump tended to interfere with performance of the task. Why does this happen? One explanation is that stress leads to a narrowing of focus. Under high stress, people concentrate on fewer features in their environment, and thus many features get less attention. So much energy is expended on anxiety that not much is left over for coping with anything else. (p. 81)

This view suggests that subjects at intense states of stress and emotion attend to only a few details with those attentional resources that are available. However, in considering the example referred to by Loftus (1980), it seems natural to expect that the parachutists were concentrating on and would remember details that were related to the emotion-eliciting situation (i.e., the jump) and that less energy would be allocated to the mental task, which must be regarded as utterly irrelevant to the main critical event (i.e., the stressful jump).

If we consider Easterbrook's (1959) theory aside from the Yerkes-Dodson (1908) law, what sort of evidence is there to support a restriction in cue utilization at states of high emotional arousal? Will an increase of autonomic arousal, concomitant with increased emotion, flood the attentional mechanisms and reduce memory processing of external and internal information, as assumed by Eysenck (1982), E. F. Loftus (1980), and Mandler (1975)? Looking at various studies on emotion and memory, one sees patterns of results that are congruent with the idea of an increased attentional narrowing in emotionally arousing situations. For example, research (i.e., real-life studies and laboratory studies) that has compared memory for central and peripheral information in emotional and neutral events demonstrates that central information of emotional events (facts or details central to the source of the emotional arousal) is retained better than corresponding details in nonemotional events; the reverse pattern is seen for information about peripheral details (see also weapon-focused studies). This pattern of results indicates that the Easterbrook hypothesis is supported in the way that attentional narrowing mediates an interaction between type of event (emotional vs. neutral) and type of detail information (central vs. peripheral).

What Factors Are Critical?

Given the results from recent laboratory research and research on real-life events, a fairly consistent pattern emerges: High emotion seems to be associated with relatively accurate memory for central details but relatively inaccurate memory for peripheral details. How can one account for these findings? Although it seems clear that people do not preserve emotional events in exceptional flashbulb detail as expressed in the idea of a Now print! mechanism or as "remarkable memories" as characterized by Yuille and Cutshall (1989), emotional events may receive some preferential processing. The last section of this article discusses the possibility that emotional events receive some special processing mediated by factors related to early perceptual processing (e.g., factors related to arousal, the distinctiveness or unusualness of an event, and attentional or preattentive factors), or late conceptual processing (e.g., post-stimulus elaboration). Consider first factors at early perceptual processing and to what extent a state of high arousal per se (the

level of arousal experienced by the rememberer) affects memory for emotional events.

Arousal

A common interpretation in the arousal and memory literature is that factors at consolidation are responsible for various interaction effects obtained. For example, that subjects presented with emotional or high-arousal items perform less well than do subjects presented with neutral or low-arousal items at an immediate test, but that the reverse result is obtained at a delayed test (cf. the Kleinsmith & Kaplan, 1963, 1964, finding discussed earlier in this article). One explanation to this Type of Event $\times$ Time of Test interaction is the consolidation view proposed by Walker (1958, 1967). In a reinterpretation of the consolidation view proposed by Müller & Pilzecker (1900) and developed by Hebb (1949), Walker (1958, 1967) argues that high-arousal events cause a state of higher cortical arousal than do neutral events. This in turn is assumed to affect the perseverative consolidation of a memory trace, which can last for a long period of time, and arousal plays an important role in this consolidation process. For conditions of low arousal, only a small amount of nonspecific neural activity conveys the fixation of the reverberating memory trace. This results in a weak consolidation and subsequently poor long-term memory performance. A high degree of arousal (i.e., more nonspecific neural activity) will produce greater reverberating activity, a stronger consolidation, and therefore a better permanent memory. The poor performance in immediate memory at conditions of high arousal (cf. Kleinsmith & Kaplan, 1963, 1964) is interpreted as indicating that the memory trace is not available to the person while the reverberation occurs. This unavailability follows from the difficulties in refiring of those neurons that are firing repeatedly in the reverberating circuit. Thus, because the neurons involved in the perseverating circuits are assumed by Walker to be limited in refiring capacity, the trace remains unavailable until the fixation process has been terminated. Under conditions of low arousal then, immediate recall is enhanced because of a lack of rapid reverberation. As an analogy to this reasoning, Walker (1967) refers to a catch-a-train metaphor: "You have no difficulty getting on board if the train is standing still. If it is moving slowly, you can make it. The faster it is going, the more difficult it is to get aboard" (Walker, 1967, p. 192).

In advocating the importance of arousal for learning, McGaugh and colleagues (McGaugh, 1983, 1992; McGaugh & Gold, 1989; McGaugh, Introini-Collison, Naghara, & Cahill, 1989) have presented extensive research indicating that memory is modulated by a variety of hormones that are released by aversive experiences, but also by positive experiences. McGaugh's findings indicate that the memory-modulating effects of hormones and drugs are dose dependent, for example, that a low dose of epinephrine (adrenalin) enhances retention (i.e., long-term retention of a footshock-motivated visual discrimination task for mice), whereas a high dose of epinephrine impairs retention.

Being more specific (and somewhat more speculative) about an arousal explanation, Gold (1986, 1992) has proposed a biological system that promotes the formation of memories for

individually based important events, such as emotional experiences. In short, the neurobiological mechanism suggested by Gold is that stressors will release epinephrine, which in turn increases circulating glucose levels. The increase in blood glucose levels has been found by Gold and others (Gold, 1986; Hall, Gonder-Frederick, Chewing, Silveira, & Gold, 1989; Manning, Hall, & Gold, 1990; Messier & Destreade, 1988) to enhance memory storage processing in animals and humans in an inverted-U dose-response curve. By way of extrapolation, Gold's research suggests that emotional events are well retained because of increased levels of blood glucose.

In the flashbulb literature, it is often claimed that the more intense the emotional reaction to the discovery of the shocking event, the better retention of attendant circumstances over time (see e.g., Bohannon, 1988, 1992; Pillemer, 1984). Thus, high levels of emotional arousal are supposed to be associated with persistence of a broad spectrum of detail information, both central and peripheral. Similar claims have been made by Yuille and Cutshall (1989) using a field-study approach and by Heuer and Reisberg (1990) using a laboratory-simulation approach. The level of arousal and affect as a predictor for detailed and vivid memories is, however, not consistently supported. For example, in the thorough study by Bohannon (1992) on people's recollection of the Challenger explosion, there was no main effect of self-reported affect on memory. A significant interaction was only seen for subjects who had been told about the shocking news from another person and not for those who were told by media (note that there was a nonsignificant difference between levels of self-rated affect between groups of subjects). A lack of significant effect of affect on memory was also seen in a study by Christianson (1989) on people's recollection of the murder of the Swedish prime minister, Olof Palme.

Although in various field studies, high levels of affect apparently tends to be associated with higher levels of overall recall, this is far from a well-established fact, and it is not justified to assume that all details are well retained because they occurred within an emotional scenario. As noted earlier in this article, several recent laboratory studies have shown that peripheral details do not persist in emotional memories. Furthermore, arguing against the notion of a general benefit of arousal and affect on detail memory are results from a survey study of people's most traumatic memories by Christianson and Loftus (1990), which showed a relationship between intensity of emotion and memory for central, but not peripheral, detail memory. Analogously, in a diary study of news memories, Larsen (1992) found no appreciable effect of arousal on memory of the ordinary news contexts. However, the probability of recalling central information ("what" and "where" questions about news events) was consistently predicted by factors related to arousal, such as perceived excitement and activity.

Moreover, assumptions regarding arousal and memory were tested in a series of studies by Christianson and colleagues. In a study by Christianson and Nilsson (1984), subjects were presented with a series of either emotional or neutral faces, each face accompanied by verbal descriptors. In this study, it was found that words associated with the arousing faces were less well remembered than words presented with neutral faces. A

subsequent study by Christianson and Mjörndal (1985) was designed with the explicit purpose of investigating to what extent the memory effects obtained by Christianson and Nilsson (1984) were mediated by a heightened level of arousal per se (i.e., independent of the emotional valence of the TBR material). Subjects were injected either with adrenalin or with saline solution and then shown the same neutral faces presented in the Christianson and Nilsson (1984) study. Despite the fact that some of the subjects were brought to a state of high emotional arousal by an adrenalin injection combined with an unfamiliar experimental situation that enhanced emotional reactions (a paradigm adopted from Schachter, 1971; Schachter & Singer, 1962; but see also Zillman's, 1978, discussion on attribution of emotional reactions), there were no differences obtained in recall or recognition performance between the two conditions. This pattern of results was confirmed in a follow-up study by Christianson, Nilsson, Mjörndal, Perris, and Tjellén (1986). The interpretation offered on the basis of these studies was that a general increase in emotional arousal as induced by an external source, like adrenalin, does not affect memory processes in the same way as a source of emotional arousal directly associated with the TBR event.⁹ Thus, a state of high arousal per se is significant as an intervening variable in explaining memory effects first and foremost when the source of arousal is an inherent property of the TBR event (cf. the causal belongingness hypothesis of mood-state-dependent retrieval discussed by Bower, 1987; see also Näätänen, 1973).

These findings challenge the view that intensity of affect, or a general increase in arousal, promotes memory for a broad spectrum of details. At the same time, there is no case for the view that memory is generally impaired during states of high arousal affect.

Unusualness and Distinctiveness

Consider the possibility that emotional events are more distinctive than neutral events. On the basis of findings by E. F. Loftus, Loftus, and Messo (1987) and G. R. Loftus and Mackworth (1978), showing that people fixate faster, more often, and for longer durations on unusual objects, it could be argued that the unusualness of emotional details or events is the critical factor that explains why emotional events are remembered differently than ordinary, neutral events (cf. Hunt & Elliott, 1980; McDaniel & Einstein, 1986). The critical question is, then, Are emotional events remembered differently because they are unusual or because emotion affects memory for reasons that go beyond the unusualness of the emotional situation?

From weapon-focus studies (Kramer et al., 1990; E. F. Loftus et al., 1987; Maass & Köhnken, 1989), it seems that the weapon-focus effect may also appear with nonemotional items, such as surprising or unusual objects instead of weapons. Thus, the unusualness and distinctiveness may account for the narrowing of attention in the weapon-focus situation and may also be critical to memory for emotional events.

The role of the unusualness as a critical factor in remembering emotional events versus ordinary, neutral events was partly investigated in a study by Christianson and Loftus (1991). Memory for an unexpected emotional event (a woman lying in a street beside a bicycle and bleeding from a head injury) was

compared with memory for an unexpected unusual event (a woman walking in a street, carrying a bicycle on her shoulder). It was found that peripheral detail information (a car seen in the distant background in both versions) was remembered equally well (or poorly) in both the emotional and the unusual conditions. However, with respect to detail information associated with the central woman (the color of the woman's clothes), memory performance for the emotional event was superior to that for the unusual event. It could, however, be argued that the central information in the unusual condition was less distinctive and less attention catching than the corresponding central information in the emotional condition and therefore less retained. On the other hand, the unusual event was far more distinctive and attention catching than a neutral, control, event (a woman riding a bicycle), but without any accompanying differences between these conditions in memory for the central detail information. Thus, it seems unlikely that the unusualness of emotional details explains the difference in memory obtained for emotional and neutral events. However, much more research is warranted to evaluate the role of unusualness and distinctiveness in remembering emotional events.

Attention

Perhaps differential distribution of attention is critical as to why people retain emotional events differently than ordinary events. From the earlier studies on central and peripheral information in emotional versus neutral events, one can only infer that differential distribution of attention or eye fixations at the time of stimulus processing promotes memory for central details of emotional events but impairs processing of peripheral details. To more closely investigate the role of attention in memory for emotional versus neutral events, Christianson, Loftus, Hoffman, and Loftus (1991) conducted an experiment in which subjects were presented with an emotional or a neutral event (using the same stimulus material as was used by Christianson & Loftus, 1991) and in which the number of eye fixations was limited to only one per slide. This was accomplished by presenting the slides for 180 ms per slide and by having each slide preceded by a fixation point that was directed to the critical TBR detail information. This procedure assured that all subjects at the time of exposure paid attention to the same critical information and for the same amount of time.¹⁰ Despite the fact that subjects in both the emotional and the neutral conditions

⁹ *External* means affecting the sympathetic nervous system and only indirectly affecting cognitive centers in the nervous system.

¹⁰ In the Christianson, Loftus, Hoffman, and Loftus (1991) study, it is assumed that the direction of attention is coordinated with fixation location. Although attention and fixation location can, under some circumstances, be dissociated, research by Posner (Posner, 1980; Posner, Cohen, Choate, Hockey, & Maylor, 1984) indicates that in real-world situations, attention usually reorients to the fovea with the eye movements, thus keeping the center of acute vision coordinated with the direction of attention. In the Christianson, Loftus, Hoffman, and Loftus study, the cue was always in the same spatial location as the fixation, that is, on the central object. In line with Posner's work (Posner, 1980; Posner, Cohen, Choate, Hockey, & Maylor, 1984), these cues were thus expected to direct attention towards fixation, keeping the two coordinated.

were equated with respect to the detail information attended to during stimulus presentation, the central detail information of the emotional condition was retained better than the corresponding detail information of the neutral condition. This pattern of results was also found in a second experiment using the same procedure but different stimulus material.

In the third experiment of the Christianson et al. (1991) study, subjects were allowed to fixate normally on an emotional or a neutral critical slide while their eye movements were monitored. Subjects in the emotional condition fixated more often on the central detail information compared with subjects in the other two conditions, yet they fixated on this detail information for shorter durations. Subjects who fixated an equal number of times on the central detail information in the two conditions were then compared with respect to memory accuracy. The results showed that even when subjects were equated with respect to number of eye fixations, subjects in the emotional condition remembered the detail information associated with the central part of the picture better than subjects in the neutral condition. Taken together, these findings cast some doubts on the hypothesis that the reason why central information is better retained in emotional events is that subjects distribute their attention differently. Whereas number of eye fixations and other attentional factors may matter, it seems not to be the entire explanation to why people retain certain detail information better from emotional than from neutral events.

Preattentive Processing

Another possible, but more speculative, interpretation of the findings in the emotion and memory literature is that certain characteristics of emotional information are perceived and retained in an automatic fashion and perhaps by preattentive mechanisms. An interesting aspect of the results presented by Christianson et al. (1991) was that the level of memory performance for subjects presented with emotional stimuli at very short exposures (180 ms) was almost the same as that found for subjects presented with the same emotional stimuli at long exposures (cf. Christianson & Loftus, 1991). Pertinent to this observation is a study by Christianson and Fällman (1990), in which it was found that very unpleasant scenic pictures (such as pictures of victims of traffic accidents, war, malady, famine) shown for very brief durations (50 ms followed by a mask slide) were better recognized than neutral scenic pictures (pictures of people in everyday situations), or very positive scenic pictures (e.g., sexual pictures of nudes or very sensual summer scenes). This congruence in memory findings obtained at short and long exposure conditions may indicate that processing of emotional information does not necessarily require much controlled processing. That is, that controlled processing (e.g., rehearsal or elaboration, see below) may not be necessary for producing these effects on memory and also that it may not be necessary to reaccess specific event information for retention of affect.¹¹ I admit that this is a very speculative interpretation, but certain characteristics of emotional events may be perceived and retained in an automatic fashion by preattentive mechanisms (cf. Neisser, 1967), which do not involve consciously controlled memory processes either at acquisition or retrieval (cf. perceptual representation system, Tulving & Schacter, 1990;

evolutionary early perceptual subsystems, M. K. Johnson & Multhaup, 1992).

Perhaps we are predisposed to retain certain characteristics of emotional information, a kind of *preattentive information processing* or *emotional priming*, reflecting some survival value from earlier stages in human evolution. In line with Öhman (1979, 1991), I assume here that an emotion-eliciting stimulus is processed from an automatic or preattentive level to a controlled conceptual level of processing. The preattentive or automatic information processing is assumed to be fast, non-conscious, independent of context, independent of processing resources, and able to carry out parallel processing of different inputs. In contrast, controlled conceptual processing requires effort, is governed by intention, and is dependent on limited processing resources.

In a situation in which a person is exposed to an emotional event, certain stimulus features may be extracted and evaluated as emotionally significant. For example, a blood stain could be regarded as emotionally significant in the sense that it represents an emotional stimulus derived from behavior systems likely to have been shaped by evolution (cf. Öhman & Dimberg, 1984; Panksepp, 1982). In terms of Öhman's (1979) model, this automatic and nonconscious evaluation activates an orienting response, and the stimulus event enters the focus of attention. Because of attention-demanding stimulus characteristics and personal involvement, controlled conceptual resources are then allocated for further stimulus analysis of the emotional event (cf. poststimulus elaboration, discussed later). Thus, in a situation with an emotional event, critical emotional details are extracted by a preattentive mechanism, which triggers attention automatically (cf. emotional priming), and controlled selection resources are subsequently allocated to the emotionally relevant information. This mode of processing would thus promote memory for central detail information, that is, details of the gist of the emotional event, but impair memory for peripheral details, that is, details that are irrelevant or spatially peripheral to the emotion-eliciting event or the source of the emotional arousal. The empirical evidence for preattentive, unconscious identification of emotionally significant information is, however, admittedly limited, and it is for future research to empirically show whether this is an advantageous interpretation for

¹¹ Many researchers in memory are convinced that people have several different memory systems that represent different stages in human development (see Tulving, 1987, for a review). There are several indications in the literature that affective components of an emotional event sometimes are encoded and retained beyond the specific details of the event itself (Christianson & Nilsson, 1989; Greenberg, Pearlman, Schwartz, & Grossman, 1983; M. K. Johnson, 1985; M. K. Johnson, Kim, & Risse, 1985; M. K. Johnson & Multhaup, 1992; Leventhal, 1984; Lewicki, 1986; Tobias, Kihlstrom, & Schacter, 1992; Zajonc, 1980, 1981, 1984). That is, sometimes people seem to remember the emotional component of an event without having access to specific event information or remember specific event information without having access to the emotional component of the event. Such dissociations suggest an interesting double dissociation between memory for emotional information and memory for specific event information and could indicate that several memory mechanisms at different levels of consciousness are involved when one remembers unpleasant or traumatic events.

some of the differences seen between memory for emotional event and memory for ordinary, neutral events.

Whatever early perceptual processes may be operating, there also may be later, conceptual processes that determine how people retain emotional information, for example, poststimulus elaboration. This alternative factor is discussed next.

Poststimulus Elaboration

Maintenance rehearsal produces poor memory performance in general compared with elaborative processing, especially in tests of recall (Craig & Jacoby, 1979; Craig & Lockhart, 1972; Craig & Tulving, 1975). There are also indications that the degree of self-reported frequency of rehearsal does not correlate with degree of memory performance in studies of emotional events. For example, Rubin and Kozin (1984) found that many flashbulb memories were not reported as being rehearsed very often (see also Bohannon, 1988; Christianson & Loftus, 1990; Larsen, 1992, for similar findings). Differential poststimulus elaboration (i.e., elaboration just after encoding) may occur when subjects are exposed to emotional events as compared with neutral events, thus contributing to the different pattern seen in studies of emotional versus neutral events. For example, compared with a neutral event, subjects presented with emotion-provoking content, such as an accident or a crime, might be more concerned with what they have just seen—about the injuries of the victim, for instance—which will lead to increased poststimulus elaboration. In terms of the levels of processing theory of Craik and Lockhart (1972) and as discussed by Craik and Blankstein (1975) and Robinson (1980), this idea implies that emotionally arousing events evoke increased attention and elaborative processing but that neutral, low-arousal events are associated with shallow maintenance processing.

Related ideas about elaboration of emotional thought content have been presented by Heuer (1987), who argues that the recall pattern for emotional events and associated details is different from that of neutral events. According to Heuer, emotional memories center around the causes of the emotions—the thoughts, feelings, and reactions of the subject—and thus cause the subject to personalize a narrative account around the central elements of the emotional experience. Heuer (1987) states that “personalization” would imply that “arousal at the time of encoding enhances long-term memory both for the ‘gist’ of an event and also for detail information peripheral to the event” (p. 1).

Heuer and Reisberg (1990) presented results indicating that subjects thought more and in a different way about emotional events compared with neutral events, that is, they thought of the emotional events in more personal, more psychological, and less schematic or abstract ways. For example, subjects presented with emotional slides are likely to be engaged by certain critical details in the slides and are likely to think about these specific details. Heuer and Reisberg also found that the pattern of how subjects attend to and rehearse emotional events shows up in the pattern of intrusion errors made by the subjects when recalling the emotional events: They made fewer errors about the emotional event itself but tended to confabulate about information associated with motives or reactions in the story.

Further support for differences in poststimulus elaboration

of emotional versus neutral events is presented by Christianson and Loftus (1991), in which one experiment was conducted to gather thoughts that were evoked in the minds of the subjects while they viewed an either critically emotional, unusual, or neutral picture in a series of slides. Analyses of these thoughts revealed that subjects’ descriptions in the emotional condition were more likely to contain expressions of affect and also more likely to make reference to the central character and the central action of the event. On the other hand, descriptions given by subjects in the neutral condition were more likely to make reference to the environment or peripheral details. Subjects in the unusual condition produced descriptions that were similar to those of the emotional subjects: They were concerned about the main action and were less likely to refer to the environment. However, in comparison with the emotional group, the subjects in the unusual condition were less explicit about the central detail information of the event.

The poststimulus elaboration hypothesis is consistent with Easterbrook’s (1959) theory in the sense that there is increased cue selectivity and restriction of attentional span in emotionally arousing situations. However, at the same time, attentional narrowing during processing of emotional events is associated with more elaborative processing of the information attended to. That is, fewer aspects of the total event are attended to, which enhances processing for central details but is detrimental to processing of peripheral or surrounding information of the emotional event. This type of increased elaborative processing is, however, not explicit from Easterbrook’s hypothesis.

The fact that subjects remember central detail information better from emotional events than from neutral events even when the detail information is shown only for very brief durations (see above) suggests that an elaboration mechanism may interact with preattentive mechanisms, which do not involve consciously controlled processing. Thus, the specific pattern of better central and poorer peripheral detail may result from the interaction between preattentive processes that alert people to orient to emotional information and more controlled processes (e.g., poststimulus elaboration) that cause them to preferentially process central versus peripheral details.

Summary and Conclusions

One primary aim of this review was to bring together empirical findings relevant to the field of eyewitness memory for negative emotional events. A second aim was to discuss this research in relation to the Yerkes-Dodson (1908) law and the Easterbrook (1959) hypothesis, because these two theories are the most frequently cited on the relation among emotion, arousal-stress, and memory, especially by researchers claiming that memory is impoverished in emotionally arousing situations (e.g., Deffenbacher, 1983; E. F. Loftus, 1979). From the review above, it is clear that emotional events are indeed remembered differently than neutral or ordinary events. However, the pattern of results from various studies reviewed proves that there are no real grounds for a simple relationship between intense emotion and memory, that is, that the more negative the emotion or stress, the poorer the memory (see, e.g., the expert consensus in the Kassin et al., 1989, study or proponents for the Yerkes-Dodson law, e.g., Deffenbacher, 1983; E. F. Loftus, 1979).

or the opposite, that intense emotion leads to generally detailed, accurate, and persistent memory (see e.g., Bohannon, 1992; Brown & Kulik, 1977; Heuer & Reisberg, 1990; Yuille & Cutshall, 1989). In fact, recent research in this field, independent of the approach used, shows that the way emotion and memory interact is a very complex matter.

In summing up the findings of the present study, one can see that highly negative emotional events are relatively well retained, both with respect to the emotional event itself and with respect to the central, critical detail information of the emotion-eliciting event—the information that elicits the emotional reaction (see e.g., Burke et al., 1992; Christianson & Loftus, 1991; Christianson et al., 1991; G. S. Goodman et al., 1986; Yuille & Cutshall, 1986, 1989; see also studies on weapon focusing). Also, certain critical detail information of emotionally arousing events and some circumstantial information are less susceptible to forgetting, compared with detail information in neutral counterparts over time (Bohannon, 1992; Brown & Kulik, 1977; Burke et al., 1992; Christianson, 1984; Christianson & Loftus, 1987; Heuer & Reisberg, 1990; Pillemer, 1984; Wagenaar & Groeneweg, 1990; Winograd & Killinger, 1983; see also studies on arousal and memory reviewed by Eysenck, 1982). In applying Easterbrook's (1959) cue-utilization hypothesis to these findings, attentional focusing along with an increased elaboration of those aspects attended to quite likely mediates a Type of Event (emotional vs. neutral) $\times$ Type of Detail Information (central vs. peripheral) interaction.

Memory for information associated with negative emotional events, that is, information preceding and succeeding such events, or peripheral information within an emotional scenario, seems to be less accurately retained, especially when tested after short retention intervals. This detrimental memory effect may recede, however, with strong retrieval support (Christianson & Nilsson, 1984; Davis, 1990; Wagenaar, 1986), if delayed testing is used (Christianson, 1984; Levonian, 1967; see also repression studies), or after repeated memory testing (P. J. Davis, 1990; Erdelyi, 1990; Erdelyi & Goldberg, 1979; Scrivner & Safer, 1988). Thus, the functional amnesia effects obtained in various studies of traumatic events are probably due to an interaction between altered encoding operations and the specific retrieval circumstances aiding consciously and unconsciously controlled reconstructive processes.

To what extent does a state of high emotional arousal per se affect memory? Even if there is a tendency in autobiographical memory studies, field studies, and laboratory studies for high arousal or intensity of emotion to be associated with increased memory performance, it is not justified to assume that all details are well retained because they occurred within an emotional scenario. Besides, a general increase in emotional arousal seems to be significant as an intervening variable when the source of emotional arousal is directly associated with the TBR event, that is, when the emotional reaction is an inherent property of the TBR event. Analogously, mood-dependent retrieval effects are obtained when the person perceives the emotion as causally belonging to the event that gives rise to it (cf. Bower, 1987).

What, then, about the apparent contradictions between results from real-life-interview studies and laboratory simulation studies? Admittedly, the literature on memory for stressful

emotional events paints a somewhat complicated picture. On the surface, it appears as if the witness-interview studies lead to different conclusions from the laboratory simulations. However, in many instances, it seems that this contradiction has to do with what particular researchers focus on. In many witness-interview studies, the researchers focus on the accuracy of memory and its persistence over time, tending to ignore or explain away the data on errors and inconsistencies (e.g., Reisberg et al., 1988; Yuille & Cutshall, 1986, 1989), whereas other researchers (e.g., Neisser & Harsch, 1990; Wagenaar & Groeneweg, 1990) focus on errors in memory and the decline of memory over time. Some researchers of flashbulb memories focus on accuracy of recall (e.g., Bohannon, 1992; Brown & Kulik, 1977), and other researchers draw attention to the errors associated with these types of memories (e.g., McCloskey et al., 1988; Neisser, 1982; Neisser & Harsch, 1990). Likewise, some researchers using the simulation paradigm (e.g., Christianson, 1984; Heuer & Reisberg, 1990) have drawn attention to the persistency of emotional memories, but others (e.g., Clifford & Hollin, 1981; Clifford & Scott, 1978; E. F. Loftus & Burns, 1982) have drawn attention to the errors made. Thus, these approaches are not as inconsistent or incompatible as they appear, that is, the data in both interview and simulation studies show both good and poor recall.

There is no question but that field research is important as a source for identifying variables for empirical investigation. However, to become fully informed, convergent methods of investigation are helpful, and the use of multiple methods—including interviews, laboratory simulations, staged events, field studies, autobiographical memory studies, and clinical studies—all contribute to further our knowledge of emotion and memory (see also G. Davis, *in press*). There are points of comparison across these methodological approaches. As pointed out by Tulving (1991), the approaches may differ, but there need not be—and there usually is not—any conflict between approaches: Normally they are complementary.

The findings reviewed in this article challenge the unidimensional view of a simple relationship between emotion and memory. The present review suggests that memory for emotional events is not just a matter of degree of emotional arousal or that emotional events are either better or worse retained than neutral events. On the basis of the findings gathered here, eyewitness memory for stressful emotional events should be understood in terms of complex interactions between type of events (emotional vs. neutral), type of detail information (central vs. noncentral details within an emotional scenario vs. surrounding, circumstantial, information or information preceding or succeeding an emotional event), time of test (immediate vs. delayed), and retrieval conditions (the presence of sufficient retrieval cues, mood, or other context cues, repeated testing, and so on). The implication of these interactions is that the Yerkes-Dodson (1908) law does not constitute an appropriate description of the relationship between emotional stress and memory performance; thus, this theory is not a pragmatically useful abstraction in evaluating eyewitness situations. In considering the expert consensus in the Kassin et al. (1989) study, there is little evidence to support the view that emotional stress is bad for memory. Such general statements seem unwarranted both in the literature and in practical settings.

To account for the findings in the emotion and memory literature, this article discusses the possibility that emotionally stressful events may receive some preferential processing mediated by factors at early perceptual processing (e.g., factors related to arousal, the distinctiveness or unusualness of an event, and attentional or preattentive factors) and factors at late conceptual processing (e.g., poststimulus elaboration). I suggest that attentional focusing (cf. Easterbrook, 1959), along with an increased elaboration of those aspects attended to, is a plausible explanation to why central detail information is better retained, whereas peripheral detail information is less well retained from emotional events compared with neutral counterparts. It is also assumed, at a more speculative level, that critical characteristics of emotional events may be extracted and processed by a preattentive and automatic mechanism, which will act as an emotional prime and thus trigger attentional selectivity and controlled memory processing (e.g., poststimulus elaboration). This discussion is admittedly speculative, but the main purpose here is to stimulate new theoretical and empirical efforts, rather than to provide a complete understanding of how emotion affects memory.

Finally, this article has exclusively focused on memory for negative or traumatic emotional events. Considering the eyewitness literature, memory for negative emotional events is of considerable importance because so many crimes and accidents involve emotional stress to the victims and witnesses. But just as surely, people remember positively valenced events as well. To draw conclusions about memory for emotional events in a broader perspective, future researchers and other reviewers need to investigate the direction of the positive emotions on memory.

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